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16. ABSTRACT

The report describes a preliminary, preoperational environmental survey conducted at a newly constructed advanced physical coal cleaning plant near Homer City, PA. The work is part of a comprehensive environmental assessment of physical and chemical coal cleaning processes performed by Battelle's Columbus Laboratories for the EPA. Multimedia grab-samples were gathered in the area to document the abundance or concentration of selected environmental parameters. Collected data were used to evaluate the air, water, and biological quality of the area both through interpretive techniques and by direct comparison with EPA Multimedia Environmental Goal (MEG) values. The ambient environment appeared to be typical of many western Pennsylvania areas which include coal mining and handling operations. The general area has been the site of numerous coal-related activities for decades. Old abandoned strip mines and on site coal-fired power plants influence the natural environment. The terrestrial and aquatic ecosystems near the Homer City plant reflect varying degrees of environmental stress. Often stream water chemistry and biological quality were adversely affected by pollution sources outside the study area, especially by acid mine drainage. Estimated permissible concentration values for several potentially hazardous elements were found to be exceeded at the plant before operations started.

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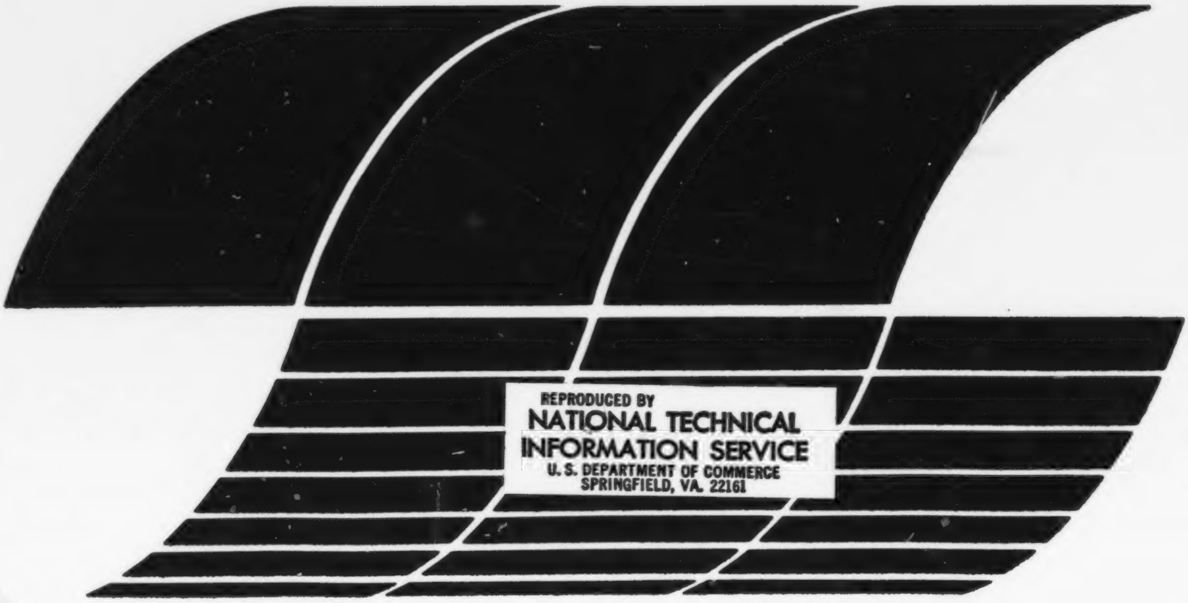

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Environmental Assessment of Coal Cleaning Processes: Homer City Power Complex Testing

by

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i.a

FOREWORD

Many elements and chemical compounds are known to be toxic to man and other biological species. Our knowledge concerning the levels and conditions under which these substances are toxic is extremely limited, however. Little is known concerning the emission of these pollutants from industrial processes and the mechanisms by which they are transported, transformed, dispersed, or accumulated in our environment.

Portions of the Federal Clean Air Act, the Resource Conservation Recovery Act, and the Federal Water Pollution Control Act require the U.S. Environmental Protection Agency (EPA) to identify and regulate hazardous or toxic substances which result from man's industrial activities. Industrial pollutants are often identified only after harmful health or ecological effects are noted. Remedial actions are costly, the damage to human and other biological populations is often irreversible, and the persistence of some environmental contaminants may endanger future populations.

EPA's Office of Research and Development (ORD) is responsible for health and ecological research, studies concerning the transportation and fate of pollutants, and the development of technologies for controlling industrial pollutants. The Industrial Environmental Research Laboratory, an ORD organization, is responsible for development of pollution control technology and conducts a large environmental assessment program. The primary objectives of this program are:

- The development of information on the quantities of toxic pollutants emitted from various industrial processes--information needed to prioritize health and ecological research efforts.

- The identification of industrial pollutant emissions which pose a clearly evident health or ecological risk and which should be regulated.

- The evaluation and development of technologies for controlling pollution from these toxic substances.

The coal cleaning environmental assessment program has as its specific objectives the evaluation of pollution and pollution control problems which are unique to coal preparation, storage, and transportation. The coal preparation industry is a mature yet changing industry and in recent years significant achievements have been made in pollution abatement.

This report deals with one portion of an IERL/RTP program which is designed to focus on the effectiveness and efficiency of coal cleaning processes as a means of reducing the total environmental impact of energy production through coal utilization. Specifically, the preoperational environmental of the advanced physical coal cleaning facility at Homer City, Pennsylvania, was studied for the purpose of providing a reference point for future comparisons.

ABSTRACT

This report describes a preliminary, preoperational environmental survey conducted at a newly constructed advanced physical coal cleaning facility located near Homer City, Pennsylvania. The work comprises a part of a comprehensive environmental assessment of physical and chemical coal cleaning processes performed by Battelle's Columbus Laboratories for the U.S. Environmental Protection Agency (EPA).

A series of multimedia grab-sampling campaigns were conducted in the study area to document the abundance or concentration of selected environmental parameters. The data collected in the campaigns were used to evaluate the air, water, and biological quality of the study area both through interpretive techniques and by direct comparison with EPA Multimedia Environmental Goals (MEG) values.

Fugitive dust was monitored using high-volume samplers at locations verified by a multiple source fugitive dust dispersion model, field-calibrated to the monitoring results and source conditions at the Homer City Station. The model is able to predict dispersion levels at various distances under a variety of meteorologic conditions.

The fugitive dust chemical analysis revealed two important phenomena. First, there are uncombusted coal dusts 2,000 meters downwind of the coal cleaning plant site that exhibit levels of lead, cadmium, arsenic, and mercury higher than those present in the whole-coal or disposed ash. Cadmium and lead values are several orders of magnitude higher than those in the whole-coal or disposed ash. Beryllium and vanadium were not found in the coal dusts but are quite evident in the source coals. Second, magnification of trace metal compounds may be attributed to the cleavage of the coal along planes where these metal compounds were concentrated. The particles released by fracturing along these planes evidently tend to become airborne due to air or vehicular movement over the coal pile.

Water quality in each of the basins monitored is a direct reflection of the types of land uses involved. The five major land uses in the

study area affecting stream water are: agriculture, mining, urban, construction, and power generation.

The stream sediments of the study area are heavily laden with metal compounds. These streams exhibit high dissolved oxygen levels and, were it not for the pH extremes and suspended solid levels, the streams could begin a rather rapid recovery. As expected in a coal region lithology, the streams had sufficiently high levels of various forms of iron, manganese, sulfur, and calcium to be of some concern.

The aquatic biota reconnaissance involved the sampling of three groups of organisms (attached algae, bottom-dwelling invertebrates, and fish) indicative of the streams' biological quality. Sampling was conducted at 14 locations in eight streams.

The subjective analysis of water quality based on the aquatic biota observed was in close agreement with the water chemistry analysis.

The terrestrial habitats evaluated within a 2-mile (3.2-km) radius of the coal cleaning plant are quite diverse and support animals common to all successional stages, especially those wildlife species associated with the early successional vegetation. Very little wetland habitat exists, and the streams and ponds which do occur in the area are unsuitable for water birds. The observation of particulate matter covering vegetation and leaf litter within 1 mile (1.6 km) of the coal pile suggests that plant biota in that area may soon begin to show signs of stress.

In summary, the ambient environment in the study area appeared to be typical of many western Pennsylvania areas which include coal mining and handling operations. In many cases, stream water chemistry and biological quality were adversely affected by pollution sources outside of the study area, especially by acid mine drainage. Power complex operations had a negative impact on the chemical and biological quality of a few of the smaller tributaries. Levels of particulates in the air were high in the vicinity of the coal storage pile, but dropped down to relatively good air quality levels off of the power station property. Terrestrial vegetation is presently diverse in the study area. Some of the more sensitive plant species close to the coal pile, however, may begin to show signs of stress due to the accumulation of coal dust and other particulates.

Both the terrestrial and aquatic ecosystems in the vicinity of the Homer City Coal Cleaning Plant reflect varying degrees of environmental stress. The general area has been the site of numerous coal-related activities for decades. Old abandoned strip mines in the vicinity as well as on-site coal-fired power plants influence the natural environment. Estimated permissible concentration (EPC) values for several elements were found to be exceeded in either air or water media at the site before the coal cleaning facility began operation.

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The advice and counsel of the EPA Project Officer, Mr. James D. Kilgroe, and others at the IERL/RTP facility were invaluable in performance of this work.

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LIST OF ABBREVIATIONS

BOD	biological oxygen demand
cfs	cubic feet per second
COD	chemical oxygen demand
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
EPC	estimated permissible concentration
gpd	gallons per day
gpm	gallons per minute
IERL	Industrial Environmental Research Laboratory
MAF	moisture- and ash-free
MATE	minimum acute toxicity effluent
MEG	multimedia environmental goals
MESA	Mining Enforcement and Safety Administration
NPDES	National Pollution Discharge Elimination Systems
PennDER	Pennsylvania Department of Environmental Resources
PTMTP	U.S. EPA's Multiple Point Source Model
ROM	run-of-mine
RTP	Research Triangle Park
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TOS	total organic sulfur
TP	total particulates

INTRODUCTION

Battelle's Columbus Laboratories has contracted with the U.S. Environmental Protection Agency (EPA) to perform a comprehensive environmental assessment of physical and chemical coal cleaning processes. The broad goal of this program (Contract No. 68-02-2163) is to establish a strong base of engineering, ecological, pollution control, and cost data which can be used to determine those coal cleaning processes that are most acceptable from the technological, environmental, and economic viewpoints. The analysis of methods for reducing overall environmental pollution through the use of cleaned coal involves mathematical and modeling techniques used for identification of optimum coal cleaning process configurations, pollution control equipment, and waste management techniques. These optimization studies require an assessment of the pollution potential of coal cleaning processes, associated facilities, and--in certain cases--the end uses of coal.

In order to obtain the field data necessary for the overall program, Battelle initiated a sampling and analysis program designed to identify the combinations of coal cleaning processes and environmental conditions which are most effective in reducing the total impact of coal use on the environment. This was accomplished through the characterization of process and effluent streams from a variety of coal cleaning facilities and their associated coal transportation, storage, and refuse disposal areas.

The recent construction of an advanced coal cleaning facility at a power complex near Homer City, Pennsylvania, provided a unique opportunity to obtain environmental data before operation of the facility for potential comparison with similar data to be obtained after operation begins. Battelle conducted a series of preoperational, multimedia, grab-sampling campaigns in a study area which included this facility, in order to document the abundance or concentrations of selected key parameters. These data were used to evaluate the air, water, and biological quality in the study area. The preoperational environmental studies, although not sufficiently long-term to be a true baseline analysis, were conducted prior to operation of the cleaning plant as a reference point for future comparisons. Additionally, an engineering-oriented evaluation of the planned refuse disposal system for the facility was accomplished. The methods and results of these studies together with preliminary interpretations are presented in subsequent chapters.

Description of the Study Area

Battelle's environmental monitoring was conducted within a study area that can be approximately bounded by a circle 4 miles (6.4 km) in diameter. The advanced coal cleaning plant in the center of the study area is about 2 miles (3.2 km) southwest of Homer City, Pennsylvania. Two of the aquatic biota sampling stations were slightly outside of the circular study area.

The six major habitat types within the study area are hardwood forest, coniferous forest, cropland, grassland, water bodies, and areas of industrial development. The forest areas are primarily hardwoods, dominated by oak and hickory. Isolated pockets of pine are present as plantations rather than naturally occurring species. Cropland is extensive in the study area, including contour and strip-cropped fields of corn, wheat, and hay. Grasslands include those areas that are presently grazed and those areas that were previously grazed or farmed and are now in a transition stage toward becoming a forest.

Stream water quality evaluated within the study area is affected by a number of land uses which are either included in the immediate study area or take place at locations farther upstream. The five major land uses affecting stream water are: agriculture, mining, urbanization, construction, and power generation. Agricultural runoff is a problem because of the hilly terrain and includes runoff from both farmland and pastures. Many upstream watersheds add acid mine drainage from abandoned or active strip mines. Almost the entire study area is on top of deep mines. As indicated earlier, Homer City, Pennsylvania, is immediately adjacent to the study area on the northeast, and Indiana, Pennsylvania, is only 5 miles (8.0 km) north of Homer City. Both towns directly or indirectly add effluents from industrial and sewage treatment facilities to Two Lick Creek before it flows through the study area. During Battelle's sampling campaigns, both the coal cleaning plant and the refuse disposal area for that facility were under construction in the study area. Finally, the study area includes the Homer City Power Station, with its associated coal storage, water treatment, and waste disposal facilities.

The Homer City Station is one part of an integrated power complex which includes two deep coal mines; coal cleaning, storage, and transport facilities; power generation facilities; and waste disposal and treatment facilities (Figure 1). Some coal used at the Homer City Station comes from the two dedicated deep mines in the power complex; other coal is hauled by truck from other mines. Solid refuse from power complex activities is deposited in three different types of disposal areas, including an ash disposal area, mine waste or "boney" piles, and the cleaning plant refuse disposal area. Liquid waste treatment facilities in the power complex include: mine and boney pile leachate water treatment facilities, an emergency holding pond constructed near the coal cleaning plant, coal storage pile runoff desilting ponds, an industrial waste treatment plant, power plant storm runoff desilting ponds, bottom ash sluice water desilting ponds, sewage treatment facilities, and ash disposal area leachate treatment ponds.

Data Comparison with MEG Values

Preoperational monitoring data from Battelle's study area near Homer City, Pennsylvania, are compared with the values listed in the Multimedia Environmental Goals (MEG) documents prepared for the U.S. EPA by Research Triangle Institute (Cleland and Kingsbury, 1977a and b). MEG values represent the maximum levels of significant contaminants which are not considered to be hazardous to man or the environment. The MEG methodology was developed to facilitate the evaluation and ranking of pollutants for the purpose of environmental assessment of energy-related processes.

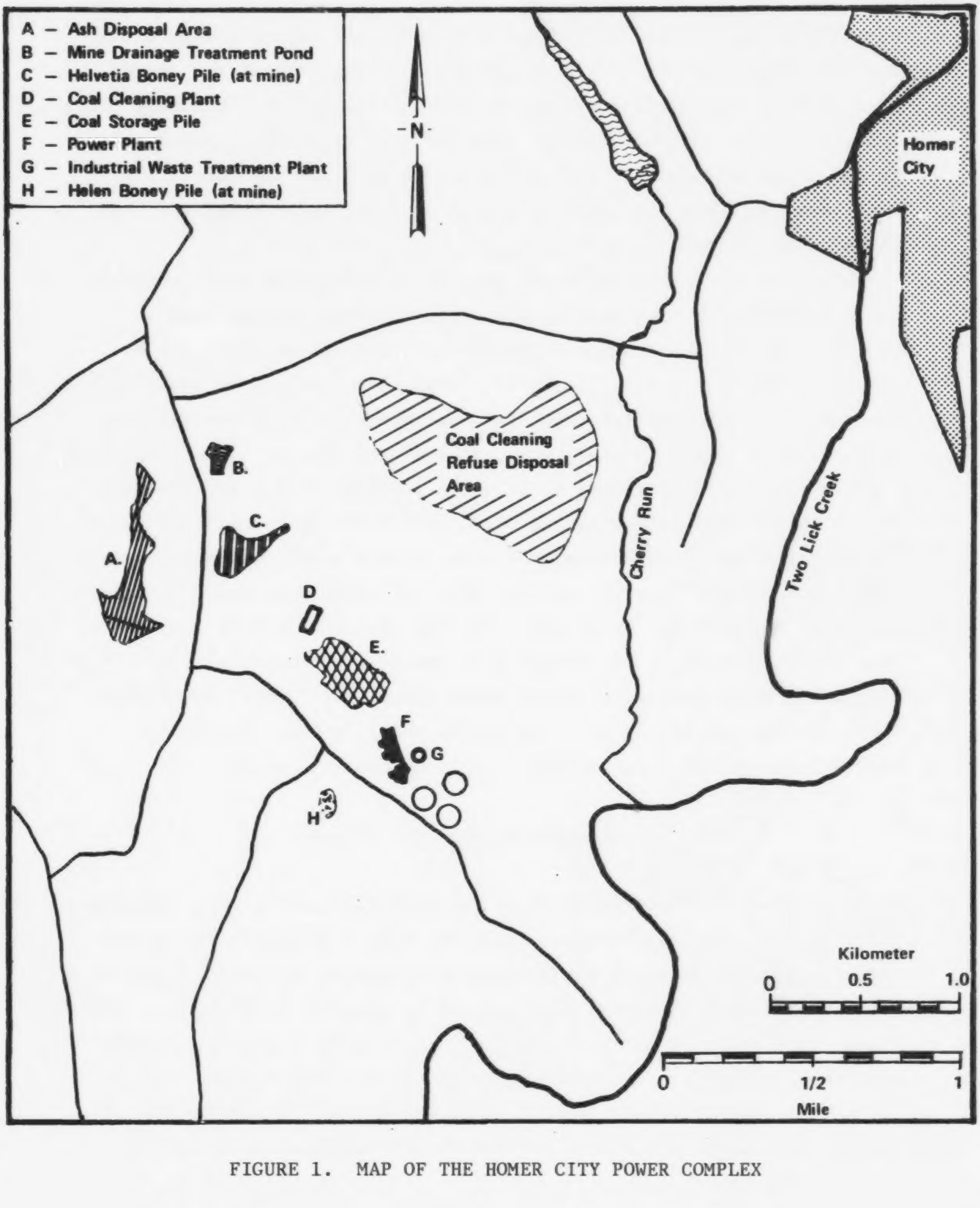
A – Ash Disposal Area
B – Mine Drainage Treatment Pond
C – Helvetia Boney Pile (at mine)
D – Coal Cleaning Plant
E – Coal Storage Pile
F – Power Plant
G – Industrial Waste Treatment Plant
H – Helen Boney Pile (at mine)
N
Homer City
Coal Cleaning Refuse Disposal Area
Cherry Run
Two Lick Creek
A.
B.
C.
D
E.
F
G
H
Kilometer
0
0.5
1.0
0
1/2
1
Mile

FIGURE 1. MAP OF THE HOMER CITY POWER COMPLEX

MEG values have been estimated for 216 pollutants by extrapolating various toxicity data by means of simple models. For most of these pollutants, maximum values have been estimated for each of the three media (air, water, and land). For each of the three media, separate maximum values have been estimated which are not considered to be hazardous to (1) human health and (2) entire ecosystems.

The MEG values that are particularly appropriate for comparison with the environmental monitoring data from Battelle's study area are those designated as estimated permissible concentrations (EPC's). EPC's are the maximum concentration of a pollutant which presents no hazard to man or biota on a continuous long-term basis. These EPC values are considered acceptable in the ambient air, water, or soil, and do not apply to undiluted effluent streams. The ambient application of EPC's corresponds to the ambient type of sampling conducted by Battelle prior to operation of the Homer City Coal Cleaning Plant.

A second type of MEG values considered in this study are those designated as minimum acute toxicity effluent (MATE) values. MATE's are concentrations of pollutants in undiluted effluent streams which will not adversely affect those persons or ecological systems exposed for short time periods. Very little of the preoperational monitoring conducted by Battelle near Homer City involved undiluted effluents, but in the case of a few pollutants, this value was the only MEG value available for comparison with Battelle's data.

Environmental Components Sampled

During the period from December, 1976, through April, 1977, a series of three preoperational grab-sampling campaigns were conducted by Battelle in the ambient media of the study area which included the Homer City Power Complex. These environmental monitoring studies involved sampling, laboratory analysis, and/or evaluation of the following components of the environment.

- Fugitive dust
- Stream water and sediments
- Aquatic biota
- Terrestrial biota
- Raw coal and fly ash
- Cleaning plant refuse disposal area
- Groundwater.

Only the first three were analyzed in sufficient detail to warrant comparison with MEG values. Samples of fugitive dust, water, and stream sediments were collected during three campaigns and analyzed for physical and chemical parameters. Aquatic biota were sampled during two campaigns for determination of indicator species, standing crop, species diversity, and chemical analysis of fish.

CONCLUSIONS AND RECOMMENDATIONS

Environmental Quality Prior to Cleaning Plant Operation

The terrestrial and aquatic ecosystems in the vicinity of the Homer City Coal Cleaning Plant reflected varying degrees of environmental stress. The aquatic ecosystems showed the greatest impact. Some of the streams in the area were inhabited by small populations of a few tolerant species. The air quality on the plant site was poor, containing high levels of particulate matter.

The terrestrial flora within 1 mile (1.8 km) of the cleaning plant were quite diverse and supported animals common to all successional stages, especially those wildlife species associated with the early successional vegetation. The area did not contain good water bird habitat. The continuing accumulation of particulate matter in a 1-mile (1.8 km) radius is expected to cause an environmental stress. Additional studies are necessary to make a detailed evaluation of impacts on the terrestrial biota.

The aquatic sampling and reconnaissance program studied a total of 14 sites in 8 streams. Stream quality was evaluated as good to poor. For example, the tributary north of the refuse area, now under construction, had good overall biological quality. Similarly, the upstream portion of the tributary south of the refuse area was judged to be of good quality.

Cherry Run was evaluated as having fair biological quality based on the number of species of fish inhabiting this stream. However, the quality of the biological community inhabiting Cherry Run has been affected by both plant and mining operations in the area. Small populations of benthic macroinvertebrates and fishes were clearly a result of the reduced water quality.

The remaining streams, Wier's Run, Rager's Pond tributary, Common Ravine, and the downstream portion of the tributary south of the refuse disposal area were all considered to have poor biological quality. In all cases poor water quality was due to aqueous releases to the environment from the existing facility. Two Lick Creek was not rated because of the small number of biological samples collected in this study.

The quality of groundwater in the area was reported to be marginal to poor and unfit for consumption.

The water of the streams that drain the power plant site was of marginal quality. Within a short distance downstream, however, conditions improved due to the buffering capability and dilution.

The stream sediments of the area were heavily laden with metals. The streams have high levels of dissolved oxygen; however, periodic low pH levels and high suspended solids prevent recovery of a high quality biological community. Oil sheens were present during all sampling periods conducted in the Common Ravine area. As expected in a coal region lithology, the streams had high levels of forms of iron, manganese, sulfur, and calcium.

Air samples collected near the coal cleaning plant contained a wide range of particulate loadings. The heaviest mass loadings were measured at 200 meters downwind of the existing coal pile. At 2000 meters downwind the measured levels dropped to levels consistent with a good air quality index.

The stations within 1000 meters of the site had a distinct diurnal loading phase. In the daytime the mass weights were 50 percent higher than the contiguous nighttime values. Obvious and significant impacts were found to extend about 1200 meters downwind. The snow cover assisted in determining the fugitive dust impact area. The average of the coal particle sizes at all stations was measured to be between 2 to 70 microns in diameter. The average ash size at all stations was in the 5 to 20 micron range. Coal was the predominant material deposited on the high-volume (hi-vol) and "Andersen" filters.

Trace element concentrations were not directly related to variance in mass weights. The average trace element concentrations were higher at 12-hour sampling sites than at the 24-hour sampling sites and were generally 500 meters downwind of the coal cleaning plant site. Southwest winds prevailed at the site for 70 percent of the time during the three sampling campaigns. These southwest winds generated the highest levels of particulate loadings. The lowest fugitive dust values were recorded under a northwest wind.

To support the fugitive dust monitoring activity, a multiple source fugitive dust dispersion model was developed. The model was field calibrated to the sampling results and source conditions at the Homer City Coal Cleaning Plant. It is probable that this model will continue to function well at other coal handling and storage facilities. This model can be used to select the optimum air sampling receptor locations in addition to predicting dispersion levels with distance and meterologic conditions.

Results of the fugitive dust chemical analysis revealed two major and interesting phenomena. First, there was uncombusted coal dust at 200 meters downwind of the coal cleaning plant site that contained higher levels of lead, cadmium, arsenic, and mercury than were present in the whole coal analysis. Cadmium and lead values were several orders of magnitude higher than corresponding values from the whole coal analysis. Beryllium and vanadium were not found in the coal dust, but were quite evident in the source coals. Second, a differential and preferential particle magnification was most likely occurring. This may be because the ROM Upper Freeport coals have a greater percent of some trace metals available for wind transport on their exposed surface cleavage planes than the percentage of these metals present in the entire chunk of coal.

The proposed design of the refuse disposal facility covers most of the important potential environmental problems in coal refuse disposal, such as slope stability, erosion, and leachate control. It is a problem, however, that the actual construction as it existed in the field on April 21, 1977, may not completely control the migration of the heavy metal laden leachate. This was principally due to the intersection of the main leachate collection line with an unconsolidated sandstone saddle bench that surfaces on the site. Another problem with the site was the construction of a storm drain trunk line at a lower vertical displacement than the leachate collection pond in the first lift area. This may permit the surface runoff leachates to bypass the leachate collection pond and treatment system.

Pollutant Toxicity Considerations and MEG Value Comparisons

Several factors confounding pollutant toxicity evaluations need to be considered when comparisons are made between estimated permissible concentration (EPC) values and field data on pollutant concentrations and biological quality. First, the EPC values have not incorporated interactive effects of pollutant combinations, such as synergism or antagonism. (Antagonistic effects between pollutants measured in stream water and sediments may explain how some EPC's for ecology were exceeded in streams that had a good biological quality rating.) Second, EPC's and field chemical data frequently involve only total elemental concentrations. Biota in the ambient environment, however, may be adversely affected only by specific compounds or ions of an element that are relatively stable in the ambient media and not by other compounds that are included in the total elemental concentration. To date, EPC values for inorganics have been determined primarily for groups of compounds which have a common parent element; comparatively few of the individual, highly toxic compounds within these groups that are also relatively stable in the environment have been evaluated for an EPC. Third, some of the water quality parameters which are extremely important in making an environmental assessment of coal-related effluents on aquatic biota do not presently have EPC's. These master parameters, including suspended solids, pH, alkalinity, etc., are planned for future EPC evaluation.

Fugitive Dust and the Terrestrial Environment

Elemental concentrations in fugitive dust which were measured in the study area exceeded both EPC and MATE values for air and soil quality. For example, three out of fifteen elements analyzed in fugitive dust had concentrations above the health-based EPC's for air quality. Comparisons with ecology-based EPC's for air quality, however, were very difficult because of the absence of ten EPC values.

Although no soil concentrations were determined, comparisons of elemental concentrations in fugitive dust were made with ecology-based EPC's for soil because of the potential problem of toxic elements leaching into the soil from fugitive dust laying on the ground. Eleven of the fifteen elements studied had concentrations in the fugitive dust which were above the ecology-based EPC's for soil. Thus, additional research needs to be conducted to determine if leaching is a problem. The existence of this type of problem, however, seems to be inconsistent with the condition of the vegetation in the area. In spite of the dust (particularly coal dust) present on the ground for some distance around the coal pile, the vegetation has not yet begun to show any obvious adverse effects.

Several recommendations can be made based on this study. First, more field experiments are needed to validate these results. The amount of available data is small and more extensive sampling and elemental analysis, particularly of soil and plant and animal tissues, are needed. These steps are necessary to determine the fate of the trace metals in the fugitive dust.

Stream Water, Sediments, and Aquatic Biota

Of the thirty water quality parameters measured in streams, only fifteen parameters have associated MEG values. Thus, some of the surface water quality data were compared with the MEG's and some were compared with other available criteria. The maximum and minimum of ten parameters exceeded the corresponding EPC's for the environment. In fact, maximum, and some minimum levels, of four pollutants (ammonia, vanadium, manganese, and zinc) exceeded the appropriate EPC values, even in streams considered to have good biological quality. This apparent discrepancy needs to be further evaluated both in terms of the validity of the proposed EPC values used, and in terms of the interactions and uniqueness of the chemical and biological conditions encountered in the study area streams.

Fifteen water quality parameters evaluated in Battelle's study do not have corresponding MEG values; these parameters were compared with criteria from U.S. EPA (1976) and McKee and Wolf (1963). Values for four of these parameters (pH, suspended solids, dissolved iron, and total organic carbon) were in close agreement with the biota quality evaluation. The three groups of aquatic biota used in the subjective evaluation of stream quality were periphyton, benthic macroinvertebrates, and fish.

Elemental concentrations in stream sediments were considerably higher than the corresponding MEG values. Maximum and minimum concentrations of eight elements in sediments exceeded the associated EPC's and MATE's for ecology. This situation occurred for seven elements, even in a stream with good biological quality. Again, the field situation and proposed EPC values need to be evaluated in more detail to determine if a discrepancy exists.

Future Studies Recommended

Additional research needs to be conducted on EPC and MATE values before they can be used to evaluate and rank pollutants for the purpose of environmental assessment. Much of this work was recommended in the initial MEG document (Cleland and Kingsbury, 1977a) and is now or will soon be in progress. For example, MEG's need to be related to the specific compounds or ionic forms of an element which are most toxic, rather than having a single value represent all compounds and ions which have a common "parent" element. Synergistic and antagonistic effects need to be considered because they may drastically change the hazard ranking of a pollutant in a specific situation. MEG's are also needed for many of the master parameters, such as the "totals" identified by Cleland and Kingsbury (1977a: 155) (e.g., total particulates) or the water quality parameters identified in this study (e.g., pH, suspended solids, dissolved iron, and total organic carbon).

In another vein, the comparison of trace element concentrations in fugitive dust to MEG values points out the need for laboratory and field research, particularly in relation to fugitive dust that consists predominantly of coal particles. First, the rates at which toxic elements leach from coal dust into a variety of soil types need to be explored. Second, the concentrations of toxic elements present in the soil around a large, open coal pile need to be determined when this pile has been in existence for a long period of time. Third, laboratory bioassay and long-term field studies need to be conducted on the effects of coal dust on plants and animals.

It is important that the type of research necessary to improve and expand the initial MEG approach to environmental assessment be completed soon. Once the MEG methodology has been refined it will become an essential part of any assessment of environmental pollution.

TERRESTRIAL ENVIRONMENT

Fugitive Dust Monitoring

Potential fugitive dust sources at the Homer City power complex were investigated during a presampling site evaluation. Some of the dust sources included an ash disposal area, boney piles at both deep mines, a coal storage pile, road dust, three power plant stacks, and construction-generated dust. The coal cleaning plant with its thermal dryers and the cleaning plant refuse disposal area were under construction during Battelle's sampling campaigns. Because these two areas were considered to be future potential sources of fugitive dust, they were considered in the selection of sampling sites.

The fugitive dust data were collected and analyzed for comparison with MEG values. The samples collected during three campaigns were analyzed for both physical and chemical parameters. Information from the survey of terrestrial biota conducted during one campaign was utilized, as later described, in attempts to confirm the results of MEG comparisons.

Fugitive dust monitoring was conducted using high-volume (hi-vol) ambient air samplers during the following three 48-hour sampling periods:

- Campaign I: 8 p.m. December 17 to 8 p.m. December 19, 1976
- Campaign II: 8 p.m. January 5 to 8 p.m. January 7, 1977
- Campaign III: 8 p.m. April 5 to 8 p.m. April 7, 1977.

The first of these three campaigns was conducted over a weekend when both coal transfer and construction activities were at a low level.

A multiple-source fugitive-dust dispersion model was used to select and verify locations for hi-vol samplers (Figure 2). This model takes into account such factors as wind speed, emission rate, particle size, and distance from selected potential dust sources located within the Homer City power complex. No dust sources outside of the power complex were incorporated in the model. On the basis of the computer-generated diffusion-modeling results, ten monitoring sites were established at

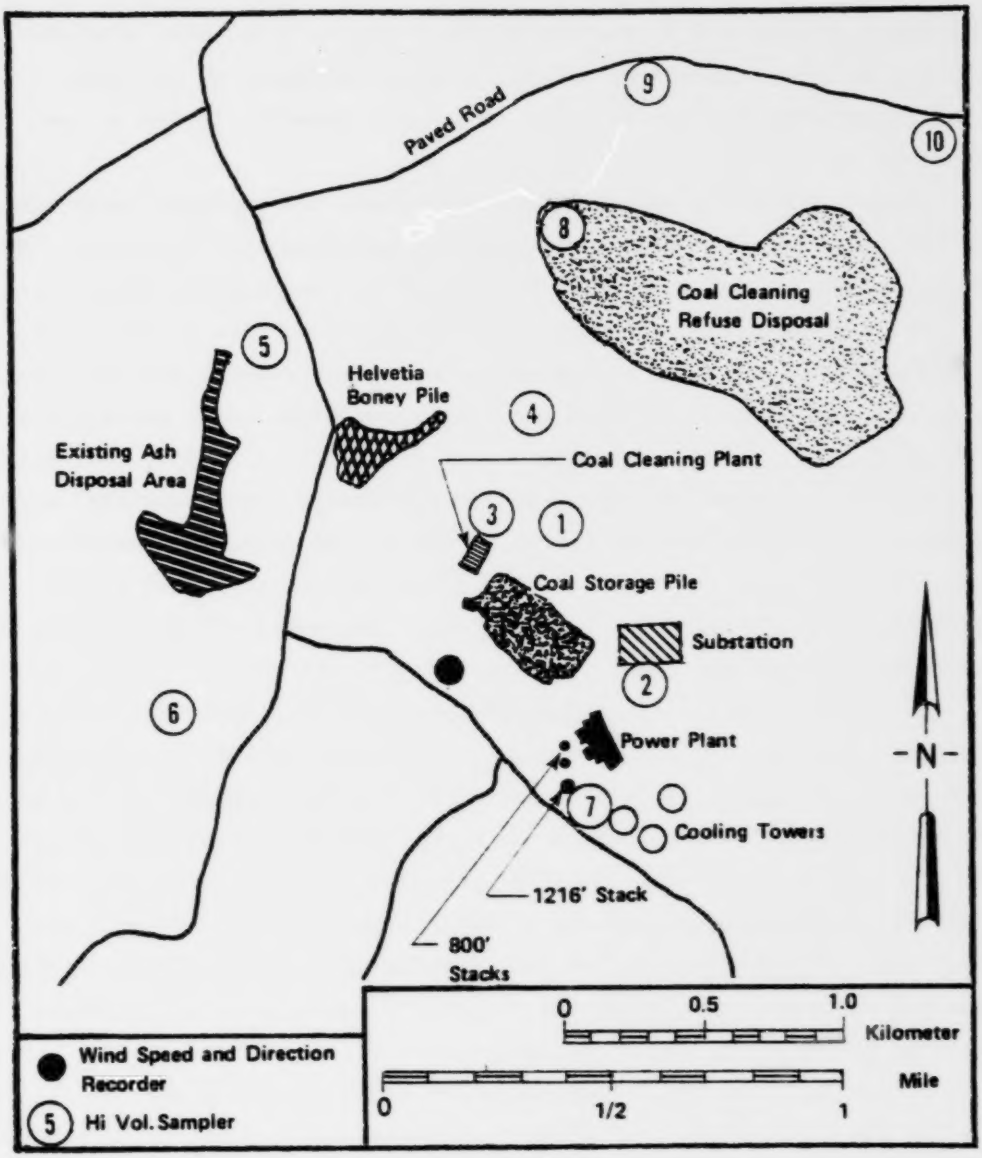
Paved Road
9
10
8
Coal Cleaning Refuse Disposal
5
Helvetia Boney Pile
4
Existing Ash Disposal Area
Coal Cleaning Plant
3
1
Coal Storage Pile
Substation
2
6
Power Plant
N
7
Cooling Towers
1216' Stack
800' Stacks
0
0.5
1.0
Kilometer
Mile
0
1/2
1
Wind Speed and Direction Recorder
5 Hi Vol. Sampler

FIGURE 2. LOCATION OF FUGITIVE DUST SOURCES AND MONITORING SITES

distances of 175 to 2200 m downwind from various local dust sources. One of the ten sites was on private property downwind of the power complex property and one site was on private property upwind of the complex.

Several potential dust sources, both local and regional, were not incorporated into the diffusion model for sampling site selection. Dust generated by vehicular traffic, parking lots, construction activities, several storage silos, and especially the dusty surface of the plant grounds was not included in the model due to its erratic and non-point-source nature. Data for the Homer City power plant stack emissions were not available in time to include in the model. In addition, four other major power stations (Keystone, Conemaugh, Seward, and Shawville) are located in the same Chestnut Ridge sector of the Allegheny Mountains as Homer City. These utilities are fed from coal mines located either directly under or near the station sites. The model did not include fugitive emission data from any of these facilities.

In order to identify the type and quantity of pollutants being emitted from fugitive dust sources, a variety of analytical techniques was employed. Particulate mass was determined by weighing the 8 x 10-inch fiberglass filters used in the hi-vol samplers before and after each of the 12- or 24-hour sampling periods. A microscopic analysis was made of particulates to provide a distinction between components such as coal dust, fly ash, pollen, or construction dust. An Andersen sampling head was used at only one of the ten hi-vol sampling sites to obtain data on the distribution of particles in five size fractions.

Particulates on the filters from the hi-vol samplers were analyzed for up to 22 elements. The analytical technique used for most elements was atomic absorption; but neutron activation, colorimetry, a specific ion meter, a total organic carbon analyzer, an LDC mercury monitor, and potentiometric titration were also used. Because large amounts of four of these 22 elements (Na, K, Ca, and Mg) were found in the blank filters, the values for these four elements were not reported. Four of the remaining 18 elements (Sb, Ti, V, Se) were analyzed only in the second or third campaign. In general, the filter exhibiting the highest percentage of coal or ash from each site was used for analysis. Data from 15 of the elements analyzed are used in the analysis and subsequent comparisons. Details of the field study are given in Appendix A.

Fugitive Dust Field Study Results

Battelle objectives in this field study were to identify the type and quantity of pollutants being emitted from fugitive dust sources associated with the power generator at the location of the future Homer City Coal Cleaning Facility. Detailed procedures, models, analysis techniques, and results are given in Appendix A. The following conclusions were drawn from these analyses of the field studies.

(1) The ash disposal area was not a principal source of fugitive dust during these sampling campaigns, probably because moisture in the ash prevented wind entrainment of ash particles.

(2) The coal storage pile was the primary source of coal dust and trace metal emissions during these sampling campaigns.

(3) Maximum concentrations of fugitive dusts were observed within 200 meters of the coal storage pile.

(4) Site 6, which is generally upwind of the plant site, was used as a background site. Total mass concentration observed at this site averaged 44 $\mu g/m^3$, the maximum concentration was 76 $\mu g/m^3$, and the minimum was 33 $\mu g/m^3$.

(5) Sites 9 and 10, which are generally downwind from the fugitive dust sources, were used to assess the impact of fugitive dust emissions leaving Homer City Power Station property. The maximum 24-hour concentrations were 45 and 82 $\mu g/m^3$, respectively, and the average concentrations were 40 and 51 $\mu g/m^3$, respectively. The data suggest that the impact of fugitive dust to the surrounding ambient air quality off the property is not significant.

(6) Trace metals were measured in the coal and the disposed ash at the Homer City facility as well as the particulate matter on selected hi-vol filter pads. There is an apparent large magnification of trace metal concentrations above the availability levels in either coal or disposed ash. Although mass concentrations were not elevated at the off-site Stations 9 and 10, trace metal magnification was apparent for these stations. For example, the average concentration of the trace metal cadmium for the three campaigns was 31 ppm* and 11 ppm at Sites 1 and 3**, respectively, while the average concentration was 206 ppm and 137 ppm at Sites 9 and 10, respectively.

(7) The primary air quality standards for particulate matter (75 $\mu g/m^3$) were exceeded during only one of the three sampling campaigns (January 5-6, 1977) at two monitoring sites which were located outside of the property line of Homer City Power Station. The upwind location measured 76 $\mu g/m^3$ of particulates and the downwind location measured 82 $\mu g/m^3$ of particulates.

Terrestrial Biota Survey

Brief, reconnaissance-type surveys of terrestrial biota were conducted on December 15 and 16, 1976, and during the week of April 11-15, 1977, in order to prepare a general description of selected ecosystem components as they existed prior to operation of the Homer City Coal Cleaning Facility and to provide a qualitative description for testing of MEG/MATE comparisons. The preoperational description of vegetation and wildlife will permit future comparisons with results of similar surveys made during the same seasons after the cleaning plant begins operation. Surveys which included field observations within a 2-mile (3.6-km) radius of the cleaning plant were made in December, 1976, and April, 1977. Both surveys involved the listing of habitat types and plant and wildlife species, but quantitative listing of all species was not possible in view of the limited time periods and seasons when surveys were possible. Scientific names of the biota observed are given in Appendix B.

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*ppm is the concentration of Cd in the particulate matter captured on the filter pad.

**Sites 1 and 3 were located within 200 meters downwind of the coal storage pile.

Dominant vegetation species within a 1-mile (1.8-km) radius of the coal cleaning facility were plotted on topographic maps (see Figure 3). A subjective assessment of the plant species encountered most frequently and an assessment of the relative sizes of the plants observed provided the criteria used as the basis for determining the dominant vegetation. In addition, all habitats within a 1- and 2-mile (1.8- and 3.6-km) radius of the cleaning facility were identified.

Vegetation

Geographically, the Homer City Coal Cleaning Facility lies within the Mixed Mesophytic Forest Region, which encompasses a region from northern Alabama to northwestern Pennsylvania. More specifically, the Homer City area lies within the Low Hills Belt of the Cumberland and Allegheny Plateaus (Braun, 1972). It is an area typified by low relief and relatively gentle slopes. Extensive cutting in this entire region has resulted in a pronounced increase in the upper slope forest types of oak and oak-hickory, which prevail today. The mixed mesophytic forest type, which dominates this area, is typically composed exclusively of hardwood. However, the Homer City area lies in close proximity to the Hemlock-White Pine-Northern Hardwood Forest Region of northern Pennsylvania and southern New York, and thus some pine and hemlock exist naturally, in addition to large areas of various coniferous species which have been planted in this region.

The terrestrial vegetation within 2 miles (3.6 km) of the coal cleaning facility has been mapped as hardwood forest, coniferous forest,

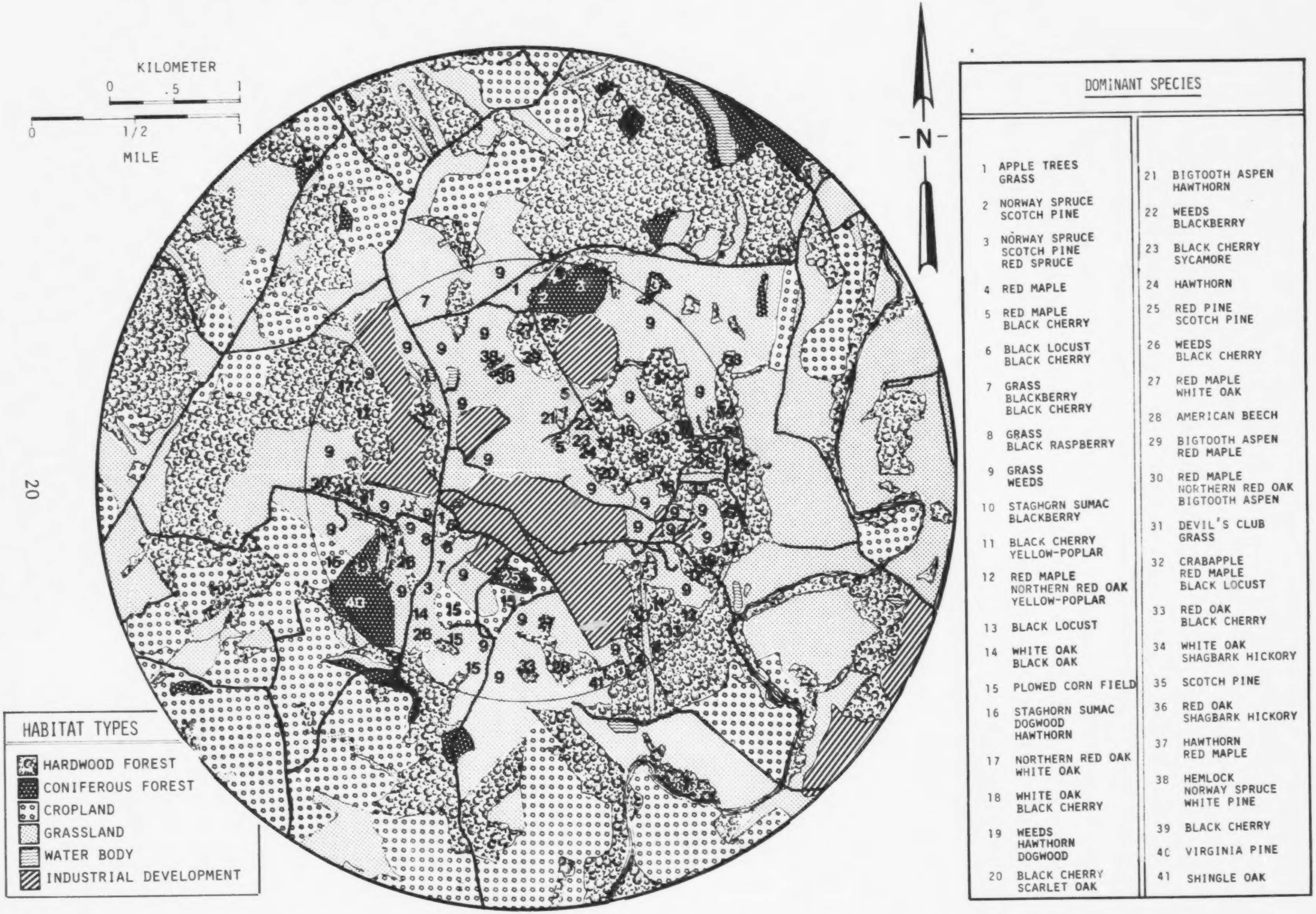

KILOMETER
0
.5
1
0
1/2
1
MILE
N
HABITAT TYPES
HARDWOOD FOREST
CONIFEROUS FOREST
CROPLAND
GRASSLAND
WATER BODY
INDUSTRIAL DEVELOPMENT
DOMINANT SPECIES
1 APPLE TREES GRASS
2 NORWAY SPRUCE SCOTCH PINE
3 NORWAY SPRUCE SCOTCH PINE RED SPRUCE
4 RED MAPLE
5 RED MAPLE BLACK CHERRY
6 BLACK LOCUST BLACK CHERRY
7 GRASS BLACKBERRY BLACK CHERRY
8 GRASS BLACK RASPBERRY
9 GRASS WEEDS
10 STAGHORN SUMAC BLACKBERRY
11 BLACK CHERRY YELLOW-POPLAR
12 RED MAPLE NORTHERN RED OAK YELLOW-POPLAR
13 BLACK LOCUST
14 WHITE OAK BLACK OAK
15 PLOWED CORN FIELD
16 STAGHORN SUMAC DOGWOOD HAWTHORN
17 NORTHERN RED OAK WHITE OAK
18 WHITE OAK BLACK CHERRY
19 WEEDS HAWTHORN DOGWOOD
20 BLACK CHERRY SCARLET OAK
21 BIGTOOTH ASPEN HAWTHORN
22 WEEDS BLACKBERRY
23 BLACK CHERRY SYCAMORE
24 HAWTHORN
25 RED PINE SCOTCH PINE
26 WEEDS BLACK CHERRY
27 RED MAPLE WHITE OAK
28 AMERICAN BEECH
29 BIGTOOTH ASPEN RED MAPLE
30 RED MAPLE NORTHERN RED OAK BIGTOOTH ASPEN
31 DEVIL'S CLUB GRASS
32 CRABAPPLE RED MAPLE BLACK LOCUST
33 RED OAK BLACK CHERRY
34 WHITE OAK SHAGBARK HICKORY
35 SCOTCH PINE
36 RED OAK SHAGBARK HICKORY
37 HAWTHORN RED MAPLE
38 HEMLOCK NORWAY SPRUCE WHITE PINE
39 BLACK CHERRY
40 VIRGINIA PINE
41 SHINGLE OAK

FIGURE 3. VEGETATION TYPES IN THE VICINITY OF THE HOMER CITY COAL CLEANING PLANT

cultivated land, or grassland (see Figure 3). Tree species observed within this 2-mile radius are listed in Appendix B.

Cultivated lands are those currently being utilized for agricultural crops. Corn, wheat, and hay are the dominant crops under cultivation. Agricultural practices in the region include stripcropping and contour plowing to minimize the erosion problems created by the hilly topography. Much of the region is too hilly for any agricultural use other than grazing.

Grassland areas include those areas currently being used for pastureland as well as those that had been grazed or farmed in the past ten to fifteen years and are now in a transition state from pure grassland to forest, with species of both types being common.

Wildlife Observations

General observations of four wildlife groups were made in conjunction with other biotic surveys conducted in December, 1976, and April, 1977. Notes were taken on all mammals, birds, reptiles, and amphibians observed during conduct of the other surveys. However, no quantitative transect or plot data were obtained. December observations were concentrated around the existing ash disposal area and the cleaning plant refuse disposal area; April observations were made primarily along streams or ponds. Emphasis in April was on terrestrial wildlife closely associated with the streams or ponds, because the primary ecological effects are expected to appear in the aquatic system. Most of the reptile and amphibian observations were made in connection with the fish seining and stocking surveys in the smaller streams. List of species and observation notes are in Appendix B.

Mammals. Seven species of mammals were observed around the Homer City power complex. Both the white-tailed deer and the raccoon appeared to be abundant, judging from the number of tracks found in most areas around the complex. The Virginia opossum, eastern cottontail, gray squirrel, and woodchuck were relatively common. The muskrat, however, was surprisingly rare for the number of streams and ponds in the area.

Birds. Eighteen species of birds were observed during a reconnaissance around the ash disposal area and the cleaning facility refuse disposal area on the afternoons of December 15 and 16, 1976. The black-capped chickadee, tufted titmouse, white-breasted nuthatch, and tree sparrow were relatively abundant around the ash disposal area; while the black-capped chickadee, cardinal, and American goldfinch were relatively abundant around the refuse disposal area. Birds observed included both permanent (year-long) residents and winter residents.

Bird observations during April 11-15, 1976, were restricted to water birds seen at streams or ponds in the vicinity of the power complex. The only water birds observed were five mallards and one pied-billed grebe. This number of species and individuals is below that expected for streams and ponds in that part of Pennsylvania during April (Todd, 1940). The absence of marshes with emergent vegetation is probably one important reason for the limited number of water birds in the area. On the other hand, additional surveys in early spring or fall would undoubtedly have resulted in the observation of a greater number of migratory waterfowl.

Reptiles and Amphibians. Five species of reptiles and amphibians were recorded in or along the streams or ponds during the April field trip. The northern two-lined salamander was the most abundant of these five species, but only eight individuals were recorded. Seven two-lined salamanders were captured at seven fish survey sites on Cherry Run and its tributaries. One two-lined salamander was captured at one of four sites on Weir's Run and its tributary. No salamanders were observed at one site each on the Rager's Pond and Common Ravine tributaries and at the one survey site on Ramsey Run. The other four reptiles and amphibians observed were the American toad, green frog, wood turtle, and queen snake.

Biological Field Study Interpretation

The following discussion and recommendations concerning the December and April reconnaissances of terrestrial biota will be helpful in referencing existing perturbations of the plants and wildlife prior to the operation of the Homer City Coal Cleaning Facility. However, no conclusions can be drawn about the environmental effects of the new facility. Results of the terrestrial studies are intended only as a reference point for use in future comparisons with more detailed surveys conducted after operation of the coal cleaning plant begins. Surveys during the other seasons of the year will also be essential in evaluating the effects of the coal cleaning facility.

The vegetation map (Figure 3) shows that the area around the coal cleaning facility is composed essentially of six habitat types, including hardwood forest, coniferous forest, cropland, grassland, water bodies, and areas of industrial development. The forested areas are primarily hardwoods, dominated by oak and hickory trees. Isolated pockets of pine are present as plantations rather than naturally occurring species. Cropland also is extensive in the area, including contour and strip-cropped fields of corn, wheat, and hay. Grasslands include those areas which are presently grazed and those areas which were previously grazed or farmed and are now in a transition stage toward becoming a forest. Logging, mining, farming, grazing, and industrial development have significantly altered the vegetation and thus the habitats available to wildlife in the area. Each of these perturbations has induced significant changes in the local fauna by reducing the amount of mature forest and creating habitats that have attracted wildlife species associated with early successional vegetation.

Measurement and field observations on the extent of gaseous and particulate pollution from coal storage, burning, and refuse disposal (see the section on Fugitive Dust Monitoring) strongly suggest that the biota, particularly the vegetation, in the immediate vicinity of the power plant are being impacted by the power complex. Visual inspection of the vegetation during April, when deciduous trees still were without leaves, did not indicate any obvious injury to the vegetation within a 1-mile radius of the cleaning facility. However, coal dust was observed on vegetation and in leaf litter up to 1 mile from the coal pile. This fugitive dust in combination with the particulate pollution from the power plant may result in the biological accumulation, transfer, and/or biomagnification of toxic elements associated with the coal and fly ash. Chemical analysis of plant and animal tissue for toxic elements known to occur in the coal used at Homer City is recommended to determine the extent of the problem prior to the long-term changes in air pollution expected to result from operation of the cleaning facility and burning and storage of cleaned coal.

Only two species of water birds were observed during the entire week of field surveys in April. Lack of marshy habitat necessary for feeding and brood rearing may be a major reason that a greater number of species was not observed. In addition, aquatic flora and fauna can be killed by dilute concentrations of heavy metals (copper, lead, zinc, etc.) (Spauling and Ogden, 1968). Because the water, sediment, and fish-tissue analyses on samples taken from the streams around the power complex showed the presence of heavy metals (see the sections on Water Quality Determinations and Aquatic Biota Survey), it is possible that some aquatic vegetation and some water bird species have been eliminated from these streams owing to the uptake of toxic heavy metals. Waterfowl habitat is often destroyed by pollution from both mining and industrial operations by decreasing the ability of the water body to support vegetation and animal life upon which waterfowl feed. For example, acid mine water has destroyed or seriously damaged more than 4,000 miles of streams in the United States, primarily by destroying food organisms (McCallum, 1964). Additional surveys during the migratory, nesting, and brood rearing seasons are suggested to determine the current importance to water birds of the streams and ponds around the Homer City power complex.

Although the survey period in early April may have been too early for sandpipers such as the spotted sandpiper (Actitis macularia) and too late for some of the early migrating waterfowl, several birds common to streams and ponds in western Pennsylvania were not observed. The wood duck (Aix sponsa), great blue heron (Ardea herodias), and belted kingfisher (Megaceryle alcyon) are three examples of birds commonly associated with small water bodies in western Pennsylvania during early April (Todd, 1940) which were not observed during the surveys around the Homer City power complex.

Of the seven species of medium- and large-size mammals recorded around the Homer City power complex, the muskrat was the least abundant. This mammal is closely associated with water and is normally found along the banks of even the smallest Pennsylvania streams (Doutt, et al., 1973). Peak density of these furbearers depends on, among other requirements, water purity and available food. Therefore, it is possible that the low number of muskrats observed in the streams around the Homer City power complex may be due, in part, to the polluted nature of most of the streams and the lack of emergent aquatic vegetation.

Many of the smaller mammals (mice, shrews, voles, etc.) not surveyed during this reconnaissance are likely to occur in the Homer City area (Doutt, et al., 1973). These small mammals are often better indicators of environmental stress than the medium- and large-size mammals because of their large numbers and small home ranges. An intensive snap-trapping program along selected transects is recommended to document population changes and to obtain tissue samples for chemical analysis of toxic trace elements found in the coal used at the Homer City power complex.

Only five species of reptiles and amphibians were recorded in or beside water bodies around the Homer City power complex. It was noted that the streams and ponds had very little marshy habitat associated with them and that the supply of aquatic insects, which serve as food for many of the reptiles and amphibians found along or in streams, was only moderate to low, except in the smallest tributaries. This lack of a plentiful food supply and an appropriate marshy habitat probably accounts for the reduced numbers of individuals and species of reptiles and amphibians in this area. However, one species of reptile was found along Cherry Run; this was the queen snake, which does not require a marshy habitat or aquatic insects. In fact, it is usually found along small stony creeks, where it feeds principally on crayfish (Conant, 1975). Cherry Run had both the stony habitat and crayfish this snake requires.

Comparison of Analytical Data with MEG Values--Terrestrial Environment

Analytical data for fugitive dust, fly ash, and raw coal sampled in the study area have been converted to the units used in the Multimedia Environmental Goals (MEG) study (Cleland and Kingsbury, 1977a and b). These data are compared with the estimated permissible concentrations (EPC's) and/or the minimum acute toxicity effluent (MATE) values.

Average concentrations of 15 elements analyzed in the fugitive dust from the study area are compared with the EPC'c for air in Table 1. Because most of the fugitive dust appeared to emanate from the coal storage pile and decline in concentration within 200-300 m downwind (Figure 4), the data have been averaged for the sampling sites located between 150-175 m and 400-1800 m downwind from the coal pile. The fugitive dust concentrations for the upwind "control" sampling location are also provided. These field data are followed by the appropriate maximum EPC's for air recommended for each element to prevent negative effects to humans or the surrounding environment during continuous long-term (chronic) exposure. A difficulty in making comparisons between observed and recommended levels of the 15 elements shown in Table 1 is that three EPC's for human health and 10 EPC's for the environment are not available.

Average concentrations for three of the elements (As, Cr, and Pb) analyzed in fugitive dust exceeded the EPC's for human health. These values have been underlined in Table 1. It is noteworthy that two of these elements (As and Cr) had concentrations above the health-based EPC even at the upwind "control" location.

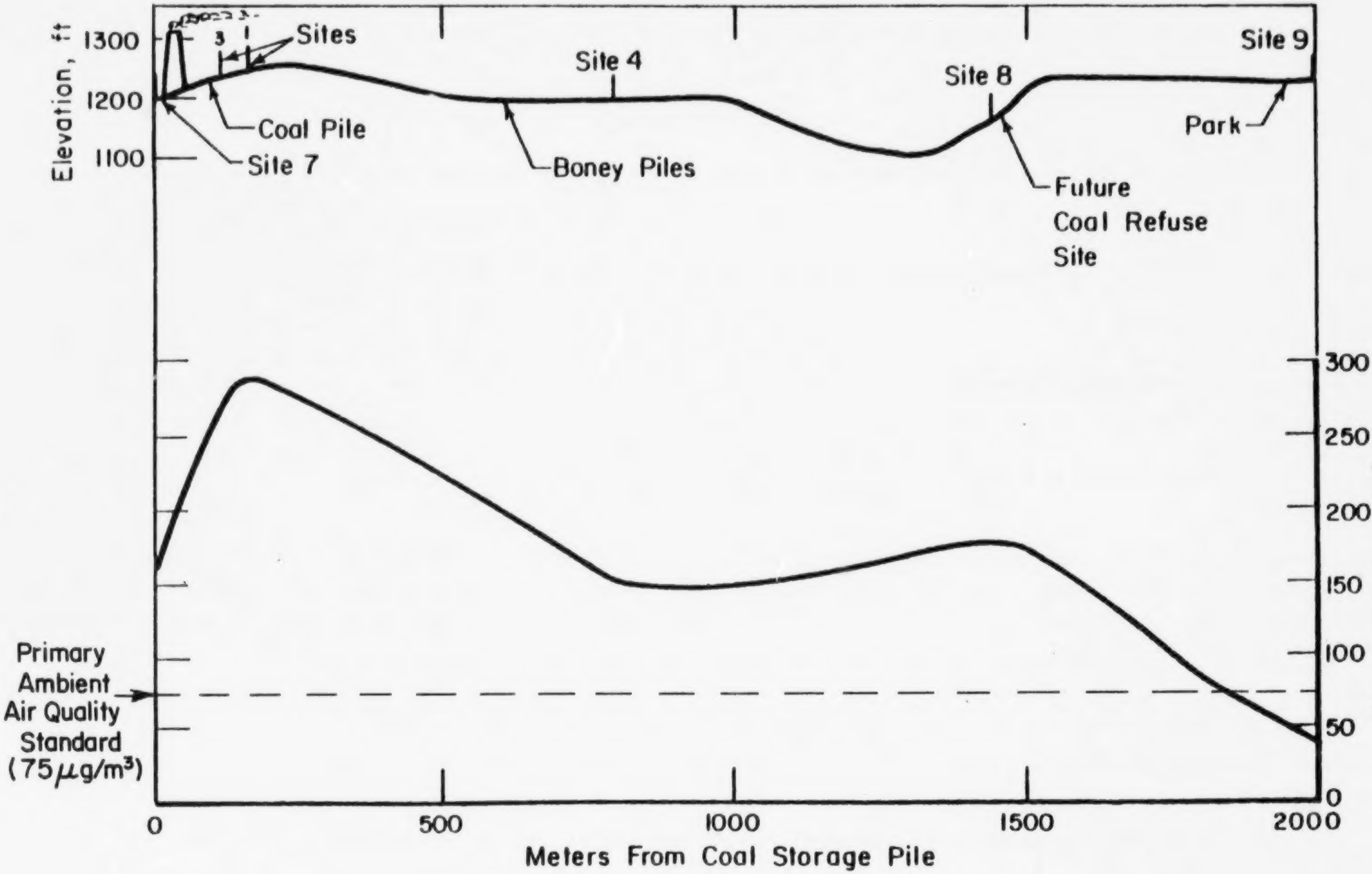


FIGURE 4. FUGITIVE DUST CONCENTRATIONS COMPARED TO A TRANSECT OF THE AREA'S TOPOGRAPHICAL RELIEF

TABLE 1. COMPARISONS OF EPC VALUES FOR AIR WITH HOMER CITY FUGITIVE DUST DATA

	Trace Element Concentrations, $\mu g/m^3$													
	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	Zn	Cl	F	V	Se
Distance from Coal Pile	Average Concentration in Fugitive Dust During 3 Campaigns at Homer City (24-hr Sampling Periods)[(a)]														
Downwind 150-175 m[(b)]	0.014	0.008	0.026	0.292	3.45	0.586	0.076	0.00056	0.015	0.44	0.35[(i)]	1.97[(i)]	5.47	ND[(j)]	0.0049
Downwind 400-1,800 m[(c)]	0.010	0.014	0.015	0.119	1.87	0.334	0.093	0.00009	0.013[(i)]	0.32[(i)]	0.22	0.82	2.03	ND	0.0026[(i)]
Upwind Control[(d)]	0.009	0.005	0.014	0.223	1.65	0.258	0.041	0.00003	0.009	0.17[(i)]	0.13	1.05	1.40	0.02[(i)]	0.0030[(i)]
EPC Category	Estimated Permissible Concentrations (EPC's)[(e)], $\mu g/m^3$														
Health	0.005	0.12[(f)]	0.002[(f)]	0.5	--[(h)]	0.36	12	16[(f)]	0.04[(f)]	14	9.5	--	--	1.2	0.5
Ecology	--	0.04[(g)]	--	--	--	1[(g)]	--	0.01[(g)]	--	--	--	--	--	0.1	0.03[(g)]

(a) All data were collected between December 1976 and April 1977.
(b) Average for sampling sites 1 and 3; downwind of coal pile.
(c) Average for sampling sites 4, 8, and 9; downwind of coal pile.
(d) Sampling site 6; upwind of coal pile about 1600 m and off of the power station property.
(e) From Cleland and Kingsbury (1977a and b).
(f) Based on a Toxic Limit Value (TLV) which recognizes the element's carcinogenic potential (Cleland and Kingsbury, 1977a and b).
(g) Based on teratogenic potential (Cleland and Kingsbury, 1977a and b).
(h) Not available.
(i) Concentrations were not available for some sampling sites during all three campaigns.
(j) ND = not detectable.

Note: For ease of making comparisons, EPC values which are used for making comparisons and the field data which exceed them are underlined.

Maximum and minimum concentrations of 15 elements analyzed in fugitive dust are compared with the appropriate EPC's for soil in Table 2. Again, the data are grouped to include sampling sites less than 200 m (i.e., 150-175 m) and greater than 200 m (i.e., 400-1800 m) downwind of the coal pile. Concentrations of the same elements in the raw coal are also shown. EPC's for protection of human health and the environment are given for 12 elements; no EPC values for iron, chlorine, and fluorine have been determined.

The majority of the elements analyzed showed maximum and frequently minimum concentrations in the fugitive dust that were far greater than the EPC levels suggested for the soil. Ten elements exceeded the EPC's for human health and 11 elements exceeded the EPC's for the environment. Both the maximum and minimum concentrations of 8 elements (As, Cd, Cr, Cu, Pb, Mn, Ni, and Se) in the fugitive dust exceeded the EPC's for both human health and the environment.

Obviously, the concentrations of toxic trace elements in fugitive coal dust that has settled to the ground does not mean that these same concentrations occur in the soil. However, studies involving soil contamination by other types of particulate deposition have shown that toxic trace elements in these particulates can cause ecosystem disruption resulting in the loss of essential nutrients and can also result in increased concentration of these toxic elements in both plants and animals. These types of effects have been demonstrated for lead smelter emissions (Jackson and Watson, 1977; Kerin, 1975) and for fly ash emissions from coal-fired power plants (Furr, et al., 1977). Dvorak, et al. (1978), have speculated that long-term exposure to uncombusted coal dust may cause changes in vegetation community structure similar to those caused by particulates from coal combustion.

Mechanisms for the movement of toxic trace elements from particulate emissions deposited on the ground to the root zone of the soil are complex (Vaughan, et al., 1975; Dvorak, et al., 1978). A partial list of the factors which influence leaching of trace elements from deposited particulates into the soil solution include (1) the size and type of particulates; (2) the amount and acidity of precipitation; (3) the concentrations and physicochemical properties of the trace elements;

TABLE 2. COMPARISONS OF EPC VALUES FOR SOIL WITH HOMER CITY FUGITIVE DUST DATA

	Trace Element Concentration, ug/g														
	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	Zn	Cl	F	V	Se
	Concentrations in Particulate at Sampling Sites within 200 m of Homer City Coal Pile (Sites 1 and 3)(a)														
Maximum	154	264	471	3,678	28,736	17,241	632	3	264	8,676	3,563	39,081	55,000	ND	33
Minimum	11	18	18	336	6,223	501	65	0.2	23	626	ND(f)	4,043	ND	ND	4
	Concentrations in Particulate at Sampling Sites Between 200 and 2,000 m of Homer City Coal Pile (Sites, 4, 8, and 9)(a)														
Maximum	238	619	667	6,061	57,576	12,857	5,603	2	545	3,007	5,152	27,278	45,600	ND	122
Minimum	34	ND	46	220	11,477	566	6	ND	ND	1,356	943	5,806	1,818	ND	1
	Estimated Permissible Concentrations (EPC's) for Soil(b)														
Health	10	0.06(c)	0.01(c)	200	--(e)	70(c)	10	50(c)	0.1(c)	17	1,000	--(e)	--(e)	1.4	2
Ecology	2	0.01(d)	10	20	--(e)	1(d)	4	1(d)	0.4	800	4	--(e)	--(e)	15	0.1(d)
	Raw Coal Concentrations Determined by Individual Analysis of Three Homer City Coal Sources(g)														
Maximum	48	0.26	35	31	48,750	17.3	74	1.1	16.8	1,329	66	0.26	108	65	ND
Minimum	22	<0.1	30	20	18,000	12	35	0.34	12.8	1,125	46	0.23	91	55	ND

(a) Data from three sampling campaigns conducted by Battelle in the study area.
(b) From Cleland and Kingsbury (1977a and b); all values were multiplied by 100 based on personal communication with Kingsbury (August, 1978).
(c) Based on carcinogenic potential (Cleland and Kingsbury, 1977a and b).
(d) Based on teratogenic potential (Cleland and Kingsbury, 1977a and b).
(e) Value not available.
(f) ND = not detectable.
(g) Coal sources include: Helen Mining Company and Helvetia Coal Company (from Upper Freeport Seam); and trucked-in coal (from Lower Kittanning Seam).

Note: For ease of making comparisons, EPC values which are used for making comparisons and the field data which exceed them are underlined.

(4) the texture, organic content, pH, and other characteristics of the soil; (5) the solubility of elements in the soil solution; and (6) the temperature of the air and soil.

The fugitive dust quantity and composition found during monitoring have probably been accumulating on the ground in a reasonably similar fashion since the power plant (including the coal storage pile) began operation in 1969. Thus, mobile elements in the settled dust may have leached into the soil. The quantity of toxic trace elements available to vegetation, however, needs to be determined by chemical analysis of the soil. In spite of any leaching of trace elements that may have increased soil concentration, the vegetation for some distance from the coal pile has not yet shown any adverse effects that were readily apparent during Battelle's field reconnaissance. An analysis of soil biota and plant diversity, however, was not conducted.

Another basis for comparison is also possible; MATE values for components in solid wastes have also been developed. Inasmuch as the deposited fugitive dusts are tantamount to being a solid waste and these deposits may contact or be absorbed or consumed by plants and animals, comparisons with MATE values for solid wastes would appear to be valid. Such a comparison has been made in Table 3. The table's structure is similar to that of Tables 1 and 2.

In Table 3, the appropriate MATE values are judged to be the ones related to ecology limits. In general, these have lower values than those for health; exceptions are mercury (Hg), chlorine (Cl), and fluorine (F), the latter two for which there are no ecology values available. Twelve of the fifteen MATE values for health are exceeded by the maximum values for both the close in (>200 m) and the more remote (<200 m) sampling sites. Eleven of the ecology values are exceeded. Comparisons of solid waste MATE values with the elemental concentrations in the raw coals are also provided in Table 3. Elemental concentrations in the raw coal exceed many of the same elemental EPC values exceeded by elements in fugitive dust. However, the levels of toxic elements in the raw coal are generally lower than the levels in the fugitive dust.

TABLE 3. COMPARISONS OF MATE VALUES FOR SOLID WASTE WITH HOMER CITY FUGITIVE DUST DATA

	Trace Element Concentration, µg/g														
	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	Zn	Cl	F	V	Se
	Concentrations in Particulate at Sampling Sites within 200 m of Homer City Coal Pile (Sites 1 and 3)[a]														
Maximum	154	264	471	3,678	28,736	17,241	632	3	264	8,676	3,563	39,081	55,000	ND	33
Minimum	11	18	18	336	6,223	501	65	0.2	23	626	ND[f]	4,043	ND	ND	4
	Concentrations in Particulate at Sampling Sites Between 200 and 2,000 m of Homer City Coal Pile (Sites, 4, 8, and 9)[a]														
Maximum	238	619	667	6,061	57,576	12,857	5,603	2	545	3,007	5,152	27,278	45,600	ND	122
Minimum	34	ND	46	220	11,477	566	6	ND	ND	1,356	943	5,806	1,818	ND	1
	Minimum Acute Toxicity Effluent (MATE's) for Solid Waste[b]														
Health	50	10	50	1,000	300[c]	50	50	2	45	18,000	5,000	260,000[d]	7,500[h]	500	10
Ecology	10	0.2	50	10	50[c]	10	20	50	2	160	20	--[e]	--[e]	30	5
	Raw Coal Concentrations Determined by Individual Analysis of Three Homer City Coal Sources[g]														
Maximum	48	0.26	35	31	48,750	17.3	74	1.1	16.8	1,329	66	0.26	108	65	ND
Minimum	22	<0.1	30	20	18,000	12	35	0.34	12.8	1,125	46	0.23	91	55	ND

(a) Data from three sampling campaigns conducted by Battelle in the study area.
(b) From Cleland and Kingsbury (1977a and b); all values were multiplied by 100 based on personal communication with Kingsbury (August, 1978).
(c) MATE values listed are for ferrous (Fe^{+2}) or ferric (Fe^{+3}) (Cleland and Kingsbury, 1977a and b).
(d) MATE value listed is for chloride ion (Cl^-) (Cleland and Kingsbury, 1977a and b).
(e) Value not available.
(f) ND = not detectable.
(g) Coal sources include: Helen Mining Company and Helvetia Coal Company (from Upper Freeport Seam); and trucked-in coal (from Lower Kittanning Seam).
(h) MATE value listed is for fluoride ion (F^-).

Note: For ease of making comparisons, MATE values which are used for making comparisons and the field data which exceed them are underlined.

AQUATIC ENVIRONMENT

Water Quality Determinations

The water quality study was designed to obtain data on the nature and characteristics of the water resources in the vicinity of the Homer City power complex prior to the operation of the coal preparation facility. The study was directed toward the establishment of some perspective as to the trends and cause/effect relationships and physical/chemical interactions between the existing land-use activities and the present water quality on and around the facility site.

Because water quality varies over time as well as area, a short-term grab-sampling effort such as that conducted at Homer City can provide only a hint as to the long-term (annual or longer) trends, even when supplemented by data from previous studies. Also, an additional complication is introduced by the fact that the study area has been in a state of flux. Major alterations to power plant effluent treatment systems and changes in regional land use have made most of the historical data obsolete or usable only with caution. The approach used was to determine the effects of each of the land uses on water quality, first additively and then in conjunction.

Sampling was conducted during three periods: December 14 through 19, 1976 (Campaign I); March 1 through 3, 1977 (Campaign II); and April 20 through 22, 1977 (Campaign III). Analytical results for 30 water quality and 9 sediment quality parameters selected for analysis in the streams and tributaries in the study area subsequently were used for comparison with 30 MEG values (Figure 5).

Location of Sampling Sites

Whenever possible, a sampling point was located at a point where historical data were available, either from previous environmental or engineering studies or as a requirement of the National Pollutant Discharge Elimination Systems (NPDES) permit for the Homer City power

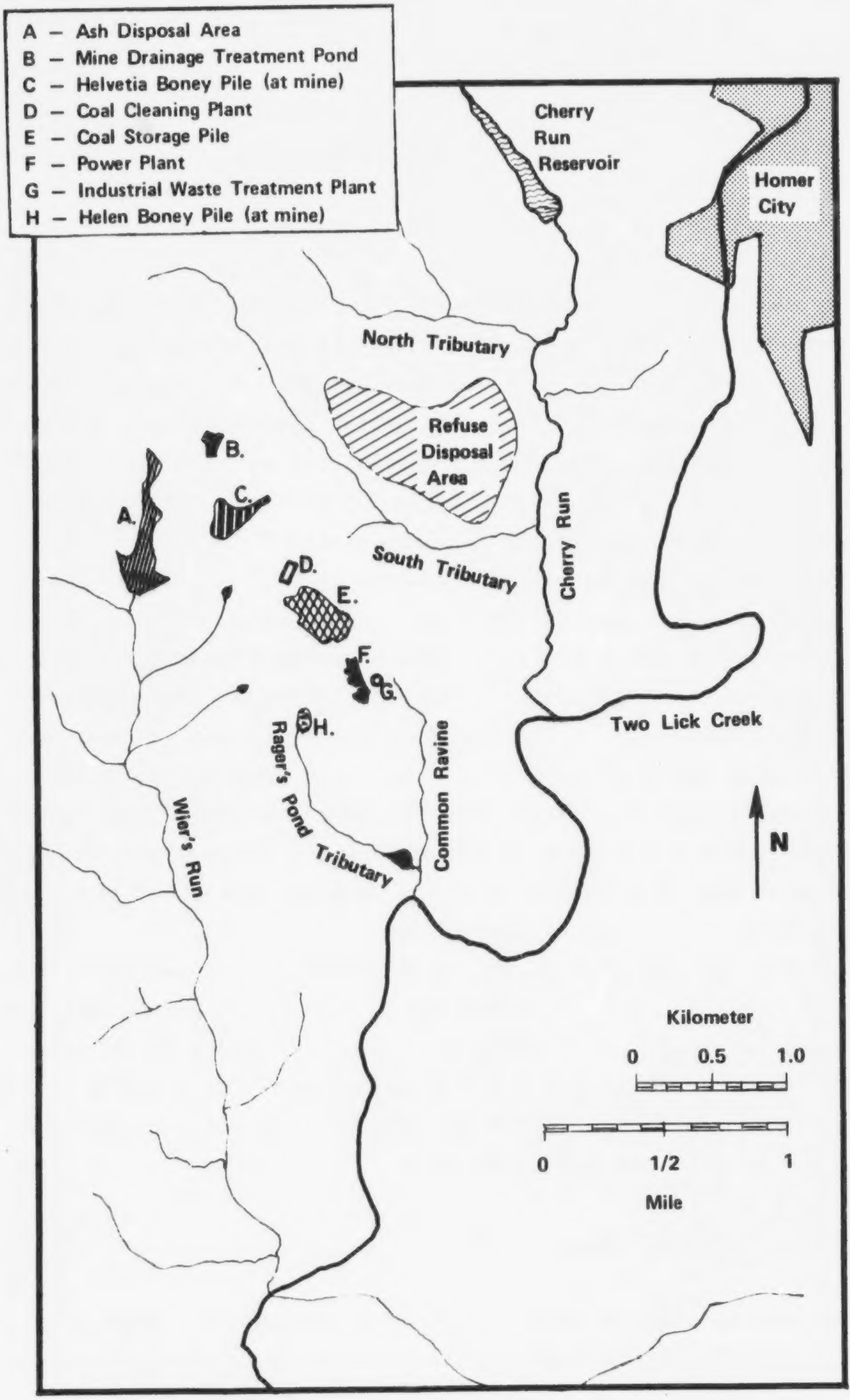

A – Ash Disposal Area
B – Mine Drainage Treatment Pond
C – Helvetia Boney Pile (at mine)
D – Coal Cleaning Plant
E – Coal Storage Pile
F – Power Plant
G – Industrial Waste Treatment Plant
H – Helen Boney Pile (at mine)
Cherry Run Reservoir
Homer City
North Tributary
Refuse Disposal Area
Cherry Run
South Tributary
A.
B.
C.
D.
E.
F.
G.
H.
Two Lick Creek
Rager's Pond Tributary
Common Ravine
Wier's Run
N
Kilometer
0
0.5
1.0
0
1/2
1
Mile

FIGURE 5. STREAMS AND TRIBUTARIES SURVEYED IN THE HOMER CITY AREA

plant. As previously stated, these data were generally less comprehensive than desired, and in several cases they have been made obsolete as a result of changes in power plant operating status. The locations of the sampling sites for surface water and sediment samples are shown in Figures 6 and 7, respectively.

Selection of Parameters

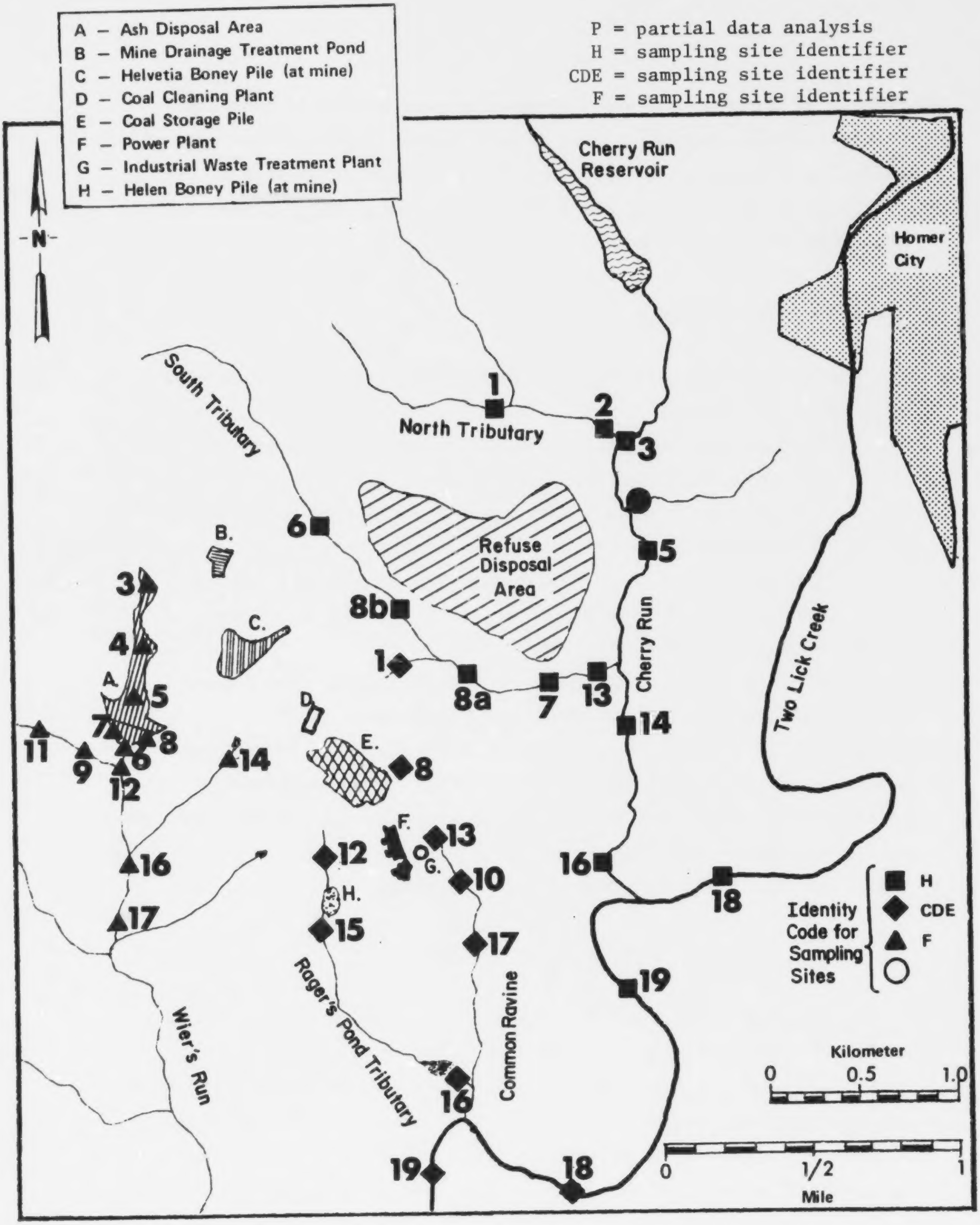
Pollutant parameters were selected on the basis of one or more of the following criteria:

- Relevance to particular land uses known to be important in the various watersheds around the plant
- Inclusion in previous water quality surveys at Homer City Station
- Appropriateness to EPA Level I assessment needs
- Presence in the source coal or in the ash
- Inclusion in NPDES monitoring data
- Suspected or known toxicity
- Likelihood of being present in any discharges from the coal cleaning plant or associated process areas.

Parameters selected are listed in Table 4. Not all parameters were monitored at every site during each campaign. In connection with parameter selection, analyses of the source coal and ash were made which confirmed that an appropriate set of parameters had been selected. The results of these analyses are given in Appendix C.

Land Use Analysis

Because the watersheds at Homer City are already influenced by a number of land uses (see Table 5) other than the proposed coal preparation plant, a cause/effect matrix was developed on the basis of the expected interactions between the land use class and the water quality (Table 6). A set of five major land use classes were identified--agriculture, mining, urban, construction, and power generation. Power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N
Cherry Run Reservoir
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Refuse Disposal Area
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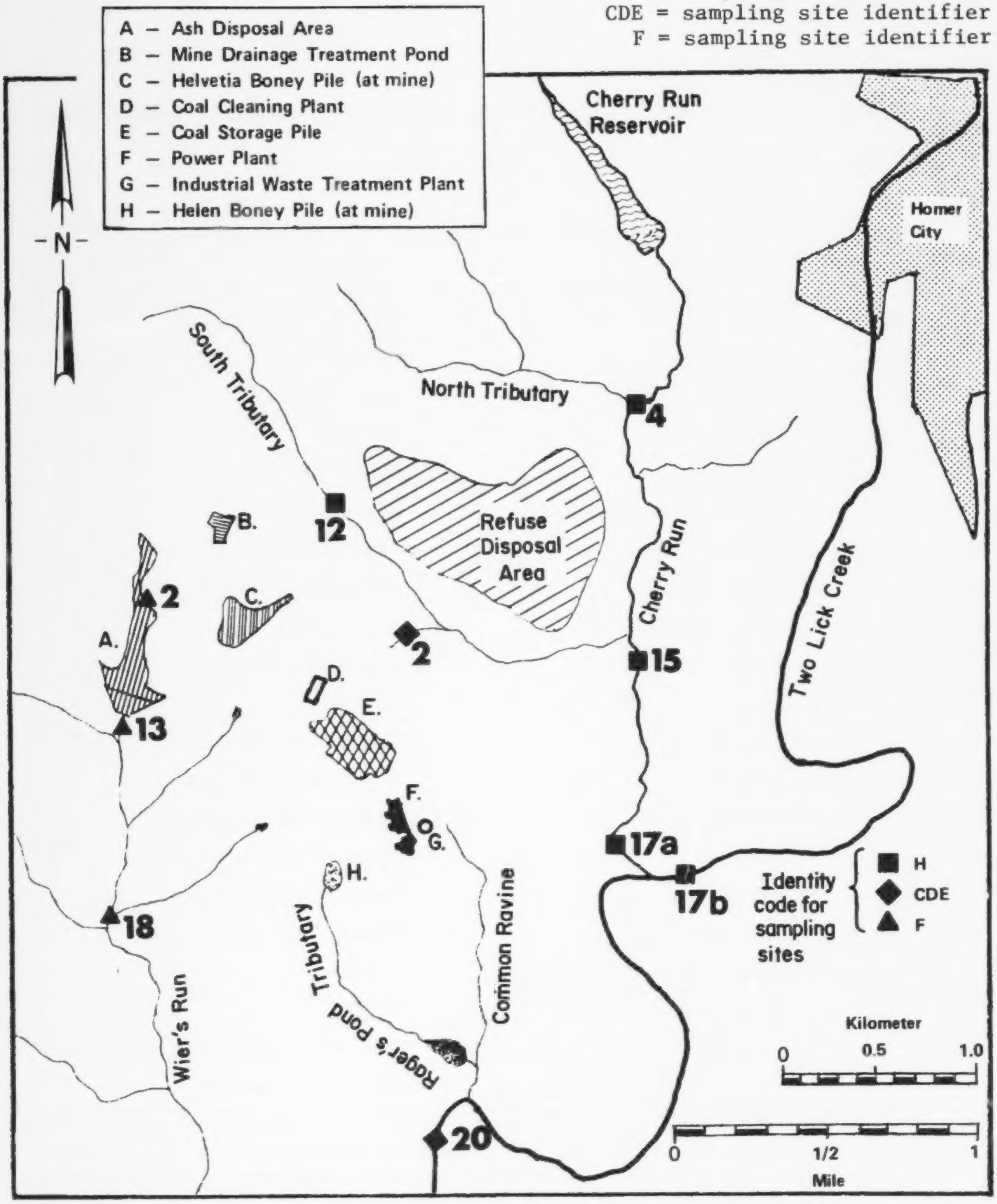
Two Lick Creek
Wier's Run
Rager's Pond Tributary
Common Ravine
A.
B.
C.
D.
E.
F.
G.
H.
1
2
3
5
6
8b
8a
7
13
14
16
18
19
3
4
5
7
8
6
11
9
12
14
16
17
1
8
12
13
10
15
17
16
19
18
Identity Code for Sampling Sites
H
CDE
F
Kilometer
0
0.5
1.0
0
1/2
1
Mile

P = partial data analysis
H = sampling site identifier
CDE = sampling site identifier
F = sampling site identifier

FIGURE 6. SURFACE WATER QUALITY SAMPLING LOCATIONS

H = sampling site identifier
CDE = sampling site identifier
F = sampling site identifier


A – Ash Disposal Area
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D – Coal Cleaning Plant
E – Coal Storage Pile
F – Power Plant
G – Industrial Waste Treatment Plant
H – Helen Boney Pile (at mine)
N
Cherry Run Reservoir
Homer City
South Tributary
North Tributary
4
12
Refuse Disposal Area
B.
C.
A.
2
2
13
D.
E.
15
Cherry Run
Two Lick Creek
F.
G.
17a
17b
H.
18
Tributary
Common Ravine
Wier's Run
Rager's Pond
20
Identity code for sampling sites
H
CDE
F
Kilometer
0
0.5
1.0
0
1/2
1
Mile

FIGURE 7. STREAM SEDIMENT SAMPLING LOCATIONS[(a)]

TABLE 4. WATER QUALITY PARAMETERS--HOMER CITY RECONNAISSANCE SURVEY

Parameter	Parameter
Arsenic[(a)]	pH
Beryllium	Acidity
Calcium	Alkalinity
Cadmium	Sulfate
Chromium	Chloride
Chromium, hexavalent	Fluoride
Copper	Suspended solids
Iron, total	Dissolved solids
Iron, dissolved	Total solids
Iron, ferrous	Volatile solids
Lead	Sulfide
Magnesium	Ammonia nitrogen
Manganese	Kjeldahl nitrogen
Mercury	Nitrate Nitrogen
Nickel	Nitrite nitrogen
Potassium	Total phosphorus
Sodium	Phenolics
Vanadium	C.O.D.
Zinc	T.O.C.
	Specific conductance
	Oil and Grease

(a) Dissolved heavy metals and nonmetals were measured at a limited number of stations during campaigns II and III; total metals and nonmetals were monitored at all stations.

TABLE 5. LAND USE INFLUENCE ON STREAM WATER QUALITY AT HOMER CITY POWER COMPLEX

Land Use $^{(a)}$ / Basin					Power Generation						
	Agriculture	Mining	Urban	Construction	Water Treatment	Wastewater Treatment	Cooling Water Discharge	Ash Sluicing	Ash Disposal	Coal Storage	Oil Drainage and Storage
Cherry Run - Main Stream	*	+	*	+						+	
Cherry Run - North Tributary	*	0									
Cherry Run - South Tributary	*		*							*	
Wier's Run	*	*	+	+					*		
Common Ravine			*		$+^{(b)}$	*	$+^{(c)}$	$o^{(b)}$		$o^{(b)}$	*
Second Ravine		*						+			*
Two Lick Creek	*	*	*	*	+	*	*	+		$+^{(b)}$	*

(a) * Indicates a land use having a major influence on water quality.
+ Indicates a land use having a minor influence on water quality.
o Degree of influence on water quality is unknown.

(b) Indirect interaction via industrial waste treatment facility.

(c) Intermittent accidental discharge.

TABLE 6. CAUSE/EFFECT MATRIX OF LAND USE CONTRIBUTIONS TO WATER QUALITY PARAMETER VALUES

Activity / Index Parameter					Power Generation						
	Agriculture	Mining	Construction	Urban	Water Treatment	Waste Water Treatment	Cooling Water Discharge	Ash Sluicing	Ash Disposal	Coal Storage	Oil Drainage and Storage
pH		X		X	X	X		X	X	X	
Acidity		X								X	
Alkalinity		X		X	X	X		X	X	X	
Sulfate		X		X		X		X	X	X	
Chloride				X		X				X	
Fluoride				X						X	
Susp. solids	X		X	X	X	X		X	X	X	
Diss. solids	X	X	X	X		X		X	X	X	
Total solids	X	X		X	X	X		X	X	X	
Volatile solids	X		X	X		X				X	
Sulfide		X						X	X	X	
Ammonia nitrogen	X			X		X					
Kjeldahl nitrogen	X			X		X					
Nitrate nitrogen	X		X	X		X					
Nitrite nitrogen	X			X		X					
Total phosphorus	X		X	X		X					
Phenols			X							X	X
Oil and grease			X								X
C.O.D.		X	X	X		X	X	X	X	X	X
T.O.C.	X		X	X		X	X			X	X
Specific conductance		X	X	X	X	X		X	X	X	
Arsenic				X		X		X	X	X	
Cadmium				X		X		X	X	X	
Chromium				X		X		X	X	X	
Copper				X		X		X	X	X	
Lead				X		X		X	X	X	
Mercury				X		X		X	X	X	
Nickel				X		X		X	X	X	
Zinc				X		X		X	X	X	
Vanadium				X		X		X	X	X	
Beryllium				X		X		X	X	X	
Iron, total		X		X		X		X	X	X	
Iron, dissolved		X						X		X	
Iron, ferrous		X								X	
Calcium		X		X	X	X		X			
Sodium				X	X	X		X			
Magnesium		X			X						
Manganese		X						X		X	
Temperature							X				

generation is further separated into water treatment (and associated sludge disposal), wastewater treatment (industrial and domestic), cooling water discharge, blowdown discharge, ash sluice overflow, ash disposal, coal storage, and oil drainage and storage. The types of pollutants associated with each land use class are described in Appendix C. In attempting to trace the fate of pollutants from these activities, the pollutant parameters ideally should be mutually exclusive for each. The monitoring of water quality in a watershed containing a number of pollution sources should resolve the origin of the pollution. Land use patterns, and thus contributions, to study site streams are presented in Table 5.

The water chemistry of the streams in the vicinity of Homer City was examined as it relates to the solubility of important elements and ions and the susceptibility of these streams to changes in water quality. In addition, chemical analysis results were acquired for the U.S. Geological Survey hydrologic and water quality benchmark station on Young Woman's Creek near Renovo, Pennsylvania (Table 7). Benchmark stations are located in undeveloped drainage basins in the major physiographic regions of the country. Renovo is approximately 85 miles (136 km) northeast of Homer City. Although this station is located in the Susquehanna River Basin rather than in the Ohio River Basin, the topography and lithology of this area are very similar to those in the vicinity of Homer City. (See Appendix C for physical descriptions of drainage basins in the Homer City area.)

The monitored parameters for Cherry Run Basin, Wier's Run, Common Ravine/Second Ravine, and Two Lick Creek have been classified into three groups according to their interactions and significance--solubility controlling species, toxic materials, and solids and nutrients. Analysis results for the three groups of parameters are discussed below. Detailed data are presented in Appendix B.

TABLE 7. CHEMICAL ANALYSIS--WATER YEAR 1973 YOUNG WOMAN'S CREEK NEAR RENOVO, PENNSYLVANIA

	Annual Average	December - April Average
Discharge, cfs	108	156
SiO_2, ppm	3.8	3.6
Ca, dissolved, ppm	3.9	3.5
Mg, dissolved, ppm	1.0	1.0
Na, dissolved, ppm	0.9	0.8
K, dissolved, ppm	1.2	1.3
Alkalinity, ppm as $CaCO_3$	5.8	3.8
SO_4, dissolved, ppm	7.3	7.5
Cl, dissolved, ppm	1.4	1.8
F, dissolved, ppm	0.1	0.1
NO_3, ppm	0.025	0.29
NO_2, ppm	< 0.01	N.D.
TP, ppm	0.01	0.01
TDS, ppm	27	26
Hard, total, ppm	22	22
Specific conductance, μmhos/cm	39	37
pH	6.2-6.9	6.2-6.9
Temperature, C	9.7	4.5
D.O., ppm	11.4	13.0
Fe, total, ppb	180	20
Mn, total, ppb	30	20
As, total, ppb	< 1	< 1
Cd, total, ppb	0	0
Cr, total, ppb	< 10	< 10
Cu, total, ppb	0	0
Pb, total, ppb	2	1
Hg, total, ppb	< 0.5	< 0.5
Zn, total, ppb	< 3	0
Suspended solids, ppm	6	5
TOC, ppm	0.5	N.D.

Source: U.S. Department of the Interior, 1974.

Cherry Run Basin

For reference purposes, the locations of the sampling sites on the main portion of Cherry Run and on the two small tributaries are shown in Figures 8 and 9.

Solubility Controls

Parameters included in this classification were iron species, sulfur species, manganese, calcium, alkalinity, acidity, and pH (Figure 10).

The water quality at most of the sites was influenced by the solubility limits for iron and manganese, which are both strongly controlled by pH. At equilibrium, both ferrous and dissolved iron should be at or below the detection limit of the analysis at pH values above 6. The iron and manganese relationships are especially relevant for Campaign I, which was characterized by low temperatures, high dissolved oxygen levels, and a solute transport mode in the form of snow-melt runoff. Significant quantities of ferrous iron were found at Sites H1, H3, and CDE1, and lesser amounts at the other sites. No active mines are known to be presently discharging to either Cherry Run or the north tributary above the sampling locations. The source of the iron was not apparent but may be historical.

Site CDE1 below the emergency holding pond and siltation ponds receives runoff from the construction area around the coal preparation plant, and surface and subsurface drainage from a portion of the coal storage pile. The water quality at this site was therefore influenced even more strongly by iron and manganese chemistry than was the water quality at the other sites.

A limited number of groundwater samples were obtained upgradient of the surface water site CDE1. Station CDE5 is located just below the coal storage pile in a manhole accessing the lateral sewers constructed to control water migration through the coal pile. Station CDE7, an industrial water well, located further to the west and slightly north of the coal pile, receives inflow from the area around the coal preparation plant and possibly from the coal mine mouth area. The exact direction of groundwater flow on this side of the coal pile has not been

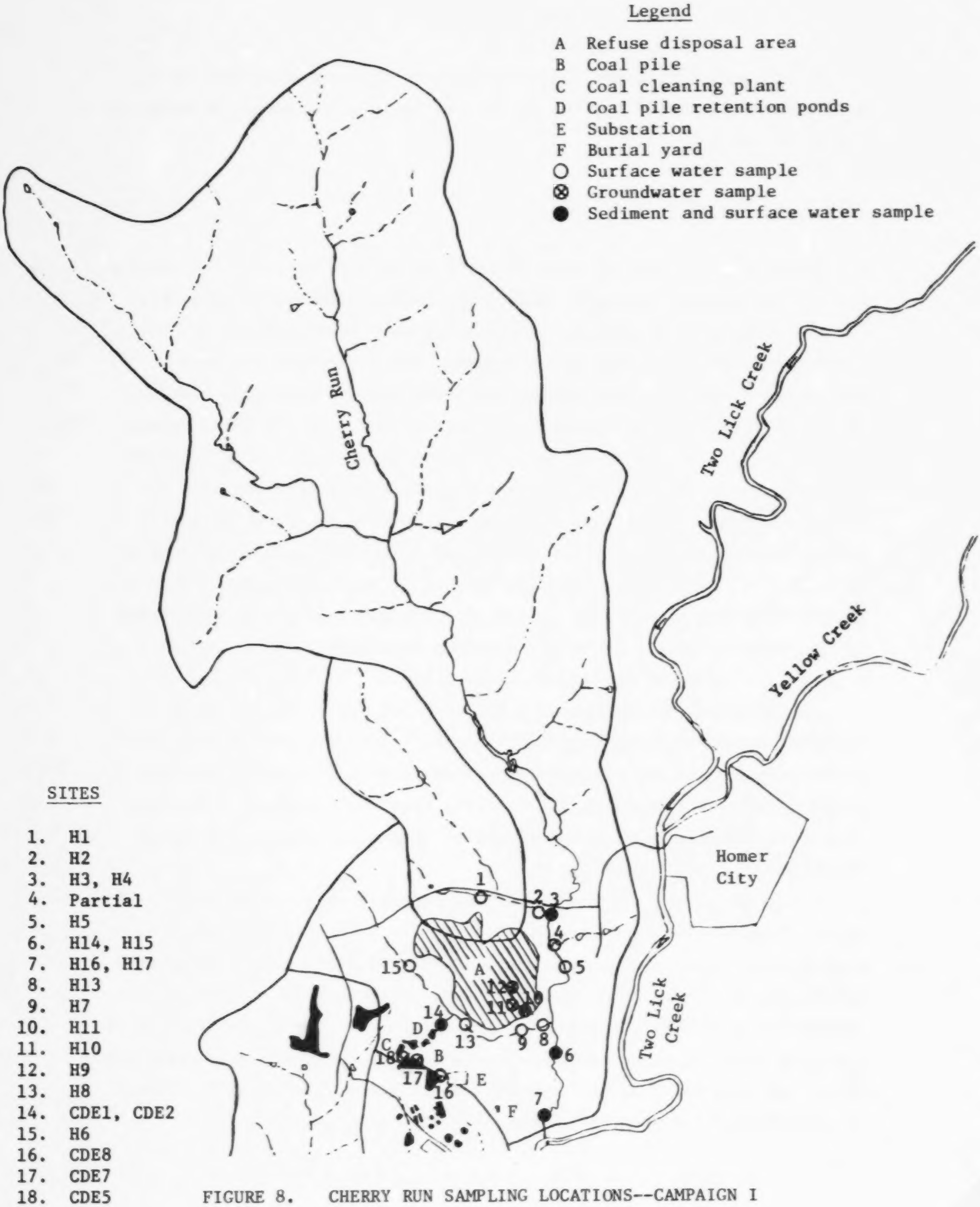
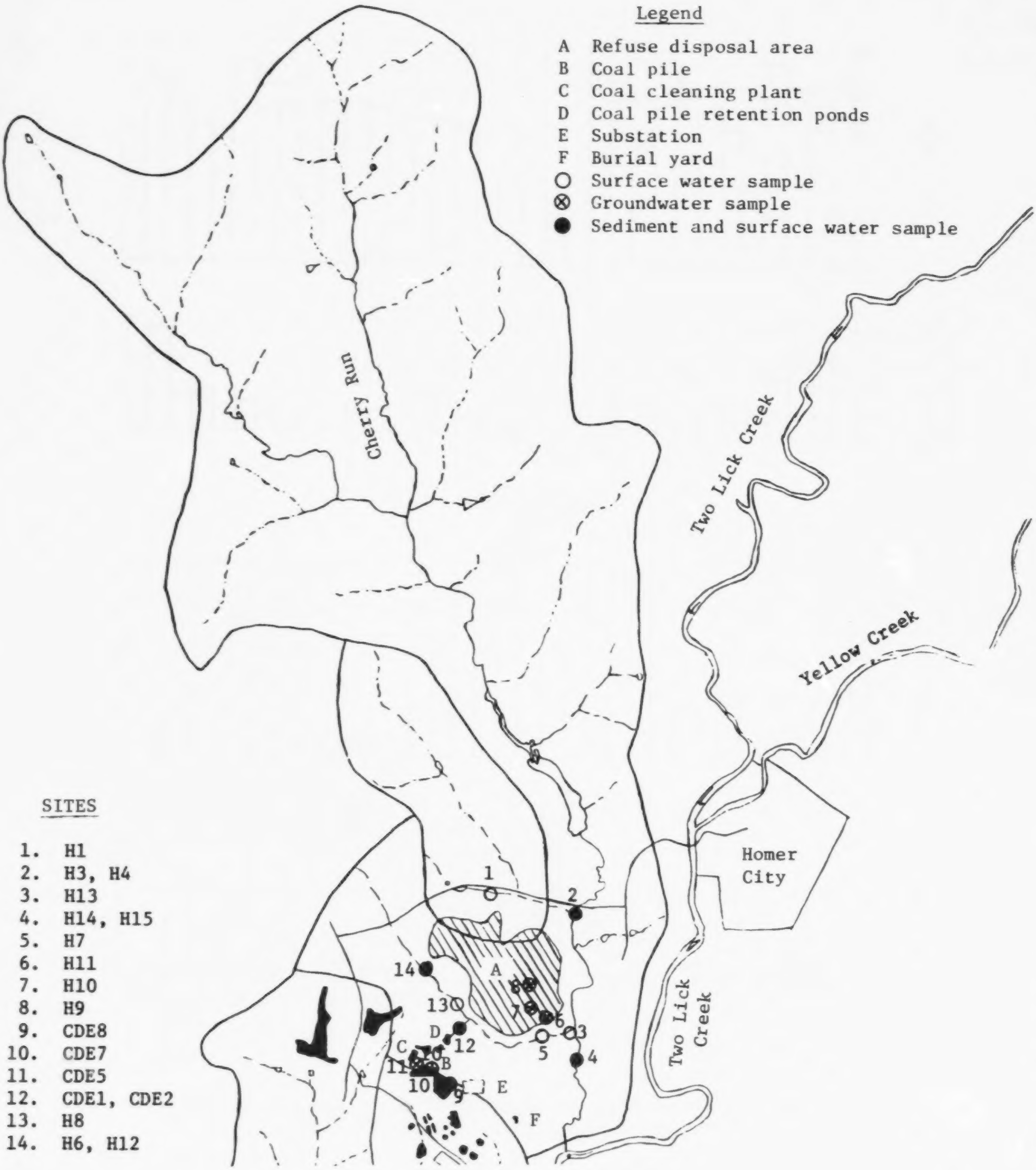

Legend
A Refuse disposal area
B Coal pile
C Coal cleaning plant
D Coal pile retention ponds
E Substation
F Burial yard
○ Surface water sample
⊗ Groundwater sample
● Sediment and surface water sample
Cherry Run
Two Lick Creek
Yellow Creek
Homer City
Two Lick Creek
A
B
C
D
E
F
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
SITES
1. H1
2. H2
3. H3, H4
4. Partial
5. H5
6. H14, H15
7. H16, H17
8. H13
9. H7
10. H11
11. H10
12. H9
13. H8
14. CDE1, CDE2
15. H6
16. CDE8
17. CDE7
18. CDE5

FIGURE 8. CHERRY RUN SAMPLING LOCATIONS--CAMPAIGN I


Legend
A Refuse disposal area
B Coal pile
C Coal cleaning plant
D Coal pile retention ponds
E Substation
F Burial yard
○ Surface water sample
⊗ Groundwater sample
● Sediment and surface water sample
Cherry Run
Two Lick Creek
Yellow Creek
Homer City
Two Lick Creek
SITES
1. H1
2. H3, H4
3. H13
4. H14, H15
5. H7
6. H11
7. H10
8. H9
9. CDE8
10. CDE7
11. CDE5
12. CDE1, CDE2
13. H8
14. H6, H12
1
2
3
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14
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D
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F

FIGURE 9. CHERRY RUN SAMPLING LOCATIONS--CAMPAIGNS II AND III

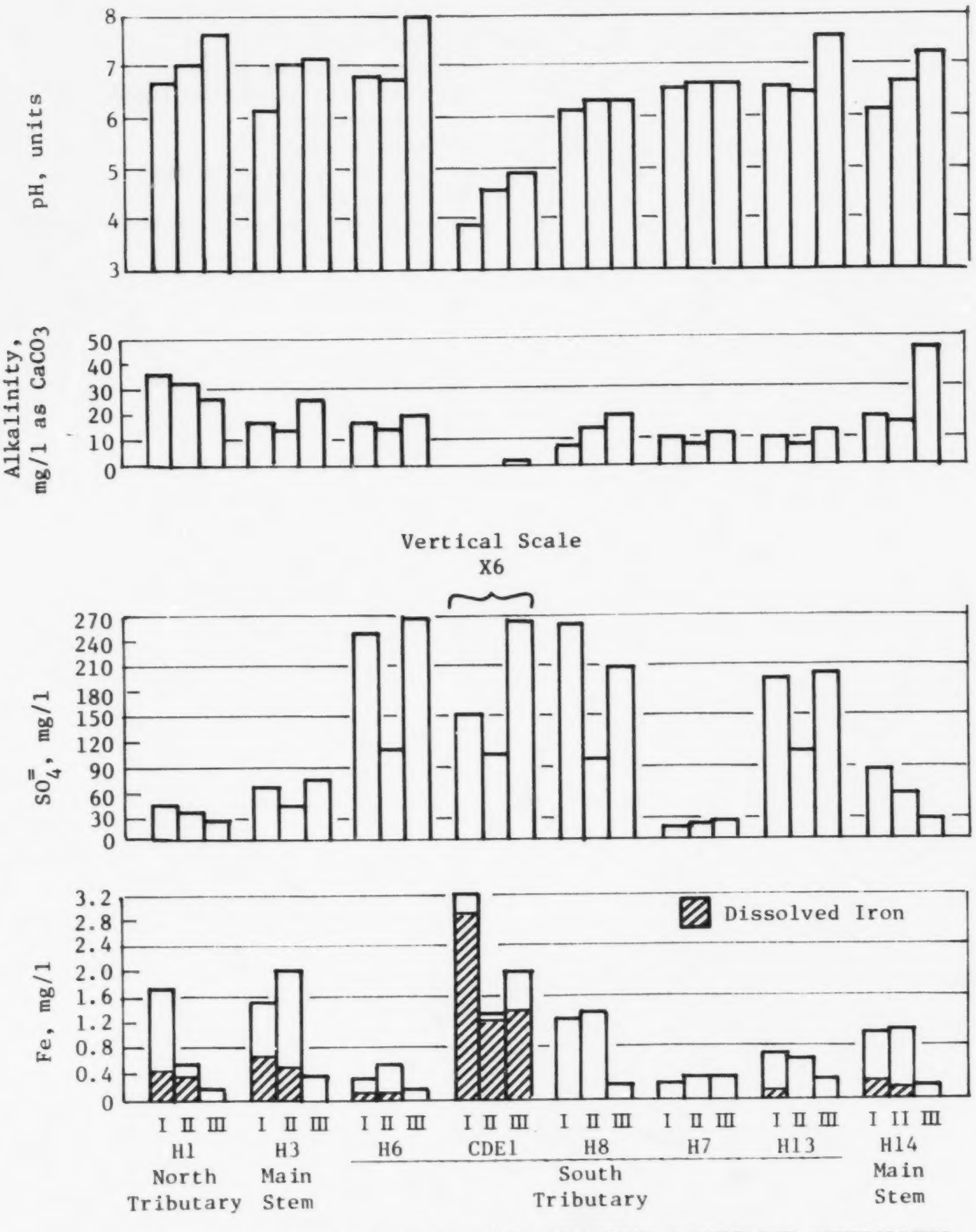

FIGURE 10. HISTOGRAMS OF SOME IMPORTANT SOLUBILITY CONTROLLING INDICATOR SPECIES IN CHERRY RUN BASIN

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

determined with precision. There is a close correlation between the shallow groundwater quality and surface water quality at CDE1. Modest amounts of dissolved oxygen (2.5-6.8 mg/l) are present and prevent the build-up of sulfides, in the near-surface groundwater. However, sulfides may be formed in the deeper percolate. The pH of these groundwaters is low enough to maintain the extremely high concentrations of iron and manganese observed. The combination of low alkalinity and high sulfate means that none of these samples is saturated with respect to calcium carbonate (as calcite), but most of the time they are saturated with calcium sulfate. Usage of the well water is very limited. Little is known about the amounts of surface or groundwater reaching Station CDE1 from these wells or from the coal pile. As the coal preparation plant site returns to a stable condition, the northwest corner of the coal pile will likely be regraded to cause the surface runoff to discharge into the desilting basins on the south side of the pile. These channels have become blocked due to earth moving during construction and because of mass-wasting from the coal pile.

Surface water quality in this area was found to be typical of Class II mine drainage in which a portion of the ferrous iron has been oxidized. The low pH in these samples effectively maintained the levels of soluble and ferrous iron observed. As this water oxidized and mixed with water from the south refuse area tributary, ferric hydroxide and occasionally calcium sulfate were in saturation equilibrium with their respective solid phases.

The south tributary also has been the receptor for runoff from the construction of siltation and treatment ponds for the refuse disposal area. Site H8 was relocated after the first campaign upstream to a point just below the discharge from the coal refuse disposal construction area. The result of this relocation was the isolation of the effects of this activity from the coal pile and plant site runoff.

Total iron increased markedly during Campaign II, presumably as a result of erosion or stream scouring. This is supported by the fact that the increase is entirely in the particulate fraction. Neither alkalinity nor sulfate concentrations were notably affected by the drainage from the back pond area. Sulfate concentrations are already high upstream of the leachate pond construction area. The source of this sulfate was not determined.

Downstream water quality in this tributary is improved by the inflow of water from a series of seepage springs. The springs contribute 9 to 20 percent of the flow from the south tributary. These springs had the best water quality in Cherry Run Basin and approach the quality of the reference stream.

Below the confluence of the south tributary with Cherry Run itself, the water quality shows no effects of the land use activities along the south tributary. The quality of the water below the confluence is equal or superior to that of the upstream water with respect to iron, alkalinity, pH, and sulfates. Water at Site H14 is nearly in equilibrium with $CaCO_3$.

Several mine discharges located on Cherry Run about 0.7 km upstream of the discharge to Two Lick Creek resulted in the reintroduction of the iron and sulfate which had been previously removed by precipitation and/or reduced in concentration by uncontaminated inflows.

One final point concerning the influences of any future development on the pH of Cherry Run or its tributaries relates to the buffer capacity. Buffer capacity at all of the stations was highly variable and generally low, primarily because of the lack of natural alkalinity (Figure 11). Discharges of low-pH water from either the emergency holding pond or accidental spillage from the sedimentation or treatment pond for the refuse leachate will have a relatively adverse impact on Cherry Run water quality in view of the existing conditions.

Toxic Materials

The trace metals and nonmetals, phenolics, and biodegradable organics are included in the Toxic Materials group. On the basis of theoretical considerations, it was not expected that analyses would show significant concentrations of any heavy metals at any distance from a source because of solubility and adsorption phenomena. Aqueous levels of total metals/nonmetals were found to be very low. Zinc was detected

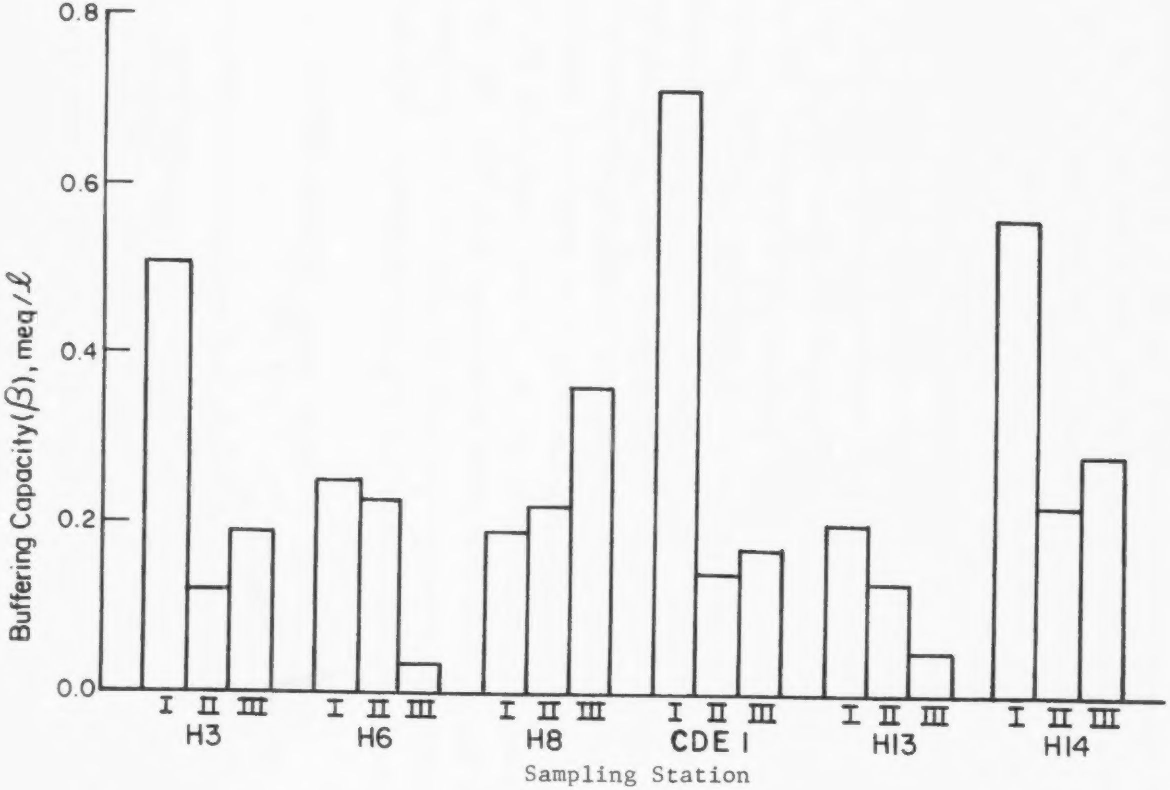

FIGURE 11. BUFFER CAPACITY--CHERRY RUN

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

the most frequently; cadmium, nickel, copper, and chromium only occasionally; and mercury, arsenic, vanadium, beryllium, and lead rarely. This trend appears to be the result of the level in the source coal and the solubility/adsorption/volatility behavior of the metal. For example, 47 to 69 ppm zinc was present in the coal samples tested. Zinc is also relatively soluble at pH values below 7.0 and thus was found in solution more frequently than cadmium or lead, which were at much lower concentrations in the coal and generally form more insoluble complexes.

Despite their low solubility, metals can become mobilized via a number of mechanisms, physical, chemical, and biological. As conditions change moving downstream, coprecipitation and adsorption are the primary modes by which trace metal ions are again made immobile. The result is an accumulation of these metals in the sediments. In the Cherry Run Basin, metals were most often found at Site CDE1. Levels of nickel and zinc are the only ones which were considered higher than the analytical detection levels. The trace metals tend to behave similarly to iron, manganese, and sulfate in that the effects of activities along the south tributary are very local and do not extend downstream into the main stem of Cherry Run. Metals were never detected at Site H14. The physical form of the metals found at Site CDE1 was also of interest (see Table 8). Samples from Campaigns II and III were filtered on site and tested

TABLE 8. FORM OF TRACE METALS IN WATER SAMPLES OBTAINED AT SITE CDE1(a)

	Observed				
	Campaign II		Campaign III		Predicted(b)
Metal	Dissolved	Total	Dissolved	Total	pH 5
Cd	0.003	0.003	n.d.(c)	n.d.	1120
Cu	0.02	0.02	0.02	n.d.	630
Ni	0.24	0.24	0.30	0.30	>59
Zn	0.46	0.43	0.62	0.64	>6000

(a) Values in mg/l.
(b) Equilibrium assumed.
(c) n.d. = not detectable.

for dissolved metals. In every case all of the total metals found in the samples were in the dissolved fraction.

These observed values are compared with the expected values on the basis of solubility. It is obvious that these dissolved metals cannot be in equilibrium with the metal oxide or hydroxide solid phase at this pH. Adsorption must therefore play an important role in the accumulation of metals to the observed concentrations.

Since adsorption takes place at surfaces, the surfaces present were characterized by their organic content and particle size distribution. The mineral sediment at most monitoring locations consisted of sand and gravel. The downstream sites (H14 and H16) also contained some silty organic material.

The iron and manganese content of these sediments is perhaps the most significant fraction in that several investigations have documented the effect of hydrous iron and manganese oxide precipitates on trace metals. Judging by the large amounts of iron and manganese in the sediments, it is believed that precipitation of these two metals constitutes one of the major mechanisms for removing the trace toxic metals from solution. As these flocs, which are composed of compounds of iron, manganese, and trace metals, settle to the bottom and age, water is squeezed out and compression settling takes place. The metals held in the interstices of the floc are then effectively immobilized unless the floc is dissolved by an acid discharge or resuspended and physically transported. This latter possibility may be important for dispersion of the metals but could not be investigated in detail.

Specific toxic organic pollutants in Cherry Run were not identified in the preoperational monitoring. Simple (Level I) analytical screening tests exist for only one class of organic compounds, namely the phenolics. Phenolics have been found to be toxic to some aquatic life at levels in excess of 200 μg/l. The maximum concentrations observed were an order of magnitude lower than the water quality criterion for phenolics (Figure 12).

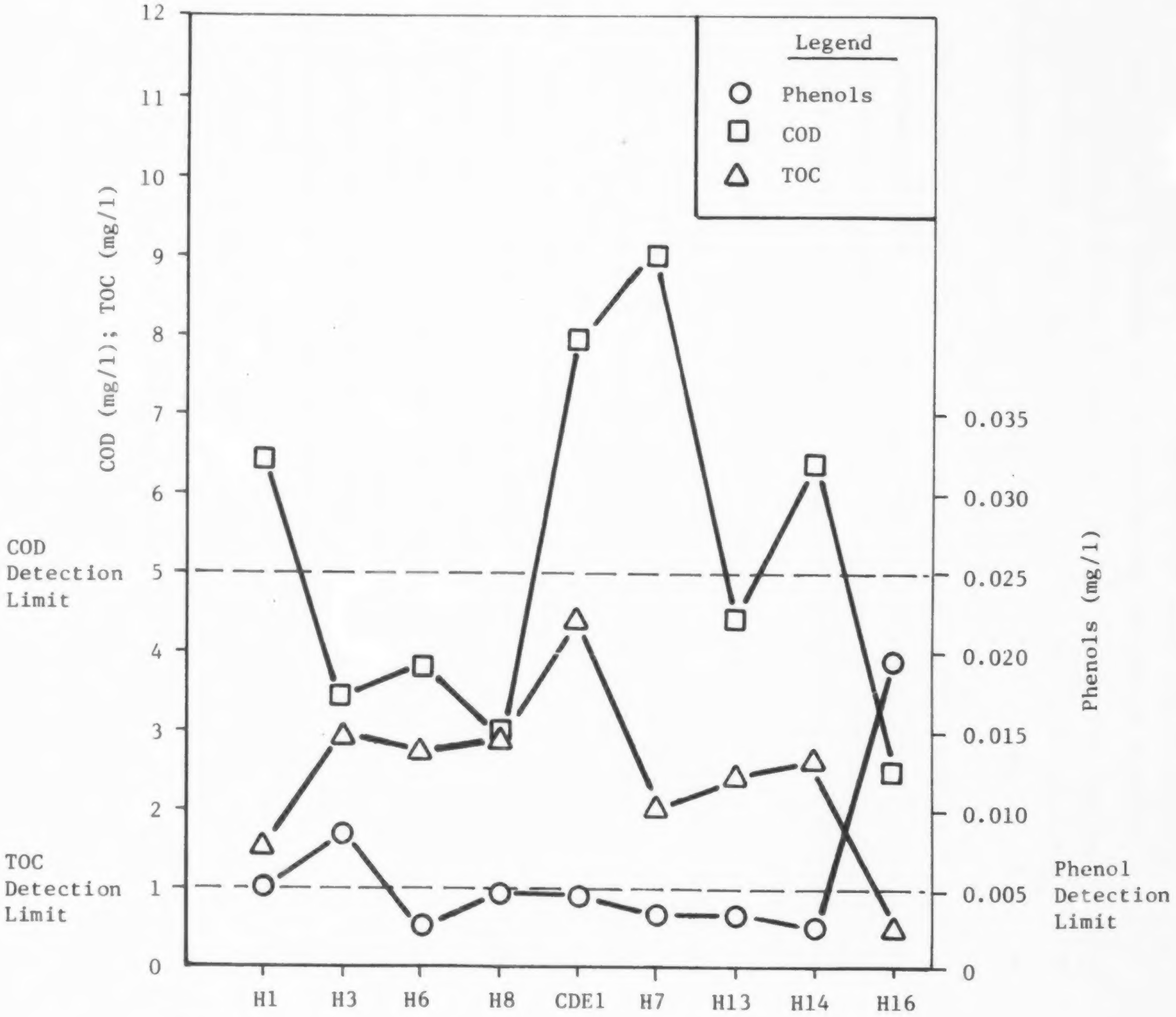

FIGURE 12. PHENOL, COD, AND TOC CONCENTRATIONS AT VARIOUS LOCATIONS IN THE CHERRY RUN WATERSHED

The organic loading data suggest that these streams have a fairly low organic load on a steady-state basis and that some of the COD is contributed by the oxidation of ferrous iron to ferric iron and of manganous (Mn^{+2}) ion to manganic (MN^{+4}) ion. An extensive determination of the assimilative capacity of Cherry Run was not performed. However, the dissolved oxygen saturation levels in the streams were always greater than 70 percent at all locations.

Nutrients and Solids

In the final category of pollutants are the nutrients and solids. Included in this classification were nitrogen species; phosphorus species; organic carbon; and suspended, volatile, dissolved, and total solids. Figures 12, 13, and 14 depict these indicators.

Although nutrients were identified in the approach section as being associated primarily with agricultural land-use activity, some ammonia can be contributed from predominantly industrial sources.

None of the measured ammonia concentrations were high enough to be considered toxic. The maximum ammonia concentration was 0.19 mg/l NH_3-N at a pH of 3.8. The water quality criterion for ammonia nitrogen was not exceeded. Ammonia is rapidly assimilated by the stream and within a few hundred meters (H8) was below the detection limit.

Concentrations of ammonia were independent of flow.

Nitrate behaved much differently from the ammonia. The influences of the agricultural land use to the north were apparent in the values at H1 and H3. The concentrations remained high at H14, primarily because of the pastureland along the east bank. A sample was obtained during Campaign I at Site H5 to characterize drainage from this land. The NO_3-N concentration of 7.0 mg/l was several times greater than the nitrate values in any of the other samples. Nitrate also showed a marked dependence on flow, with the values during wet weather in Campaigns I and II being much higher than those during dry weather in Campaign III.

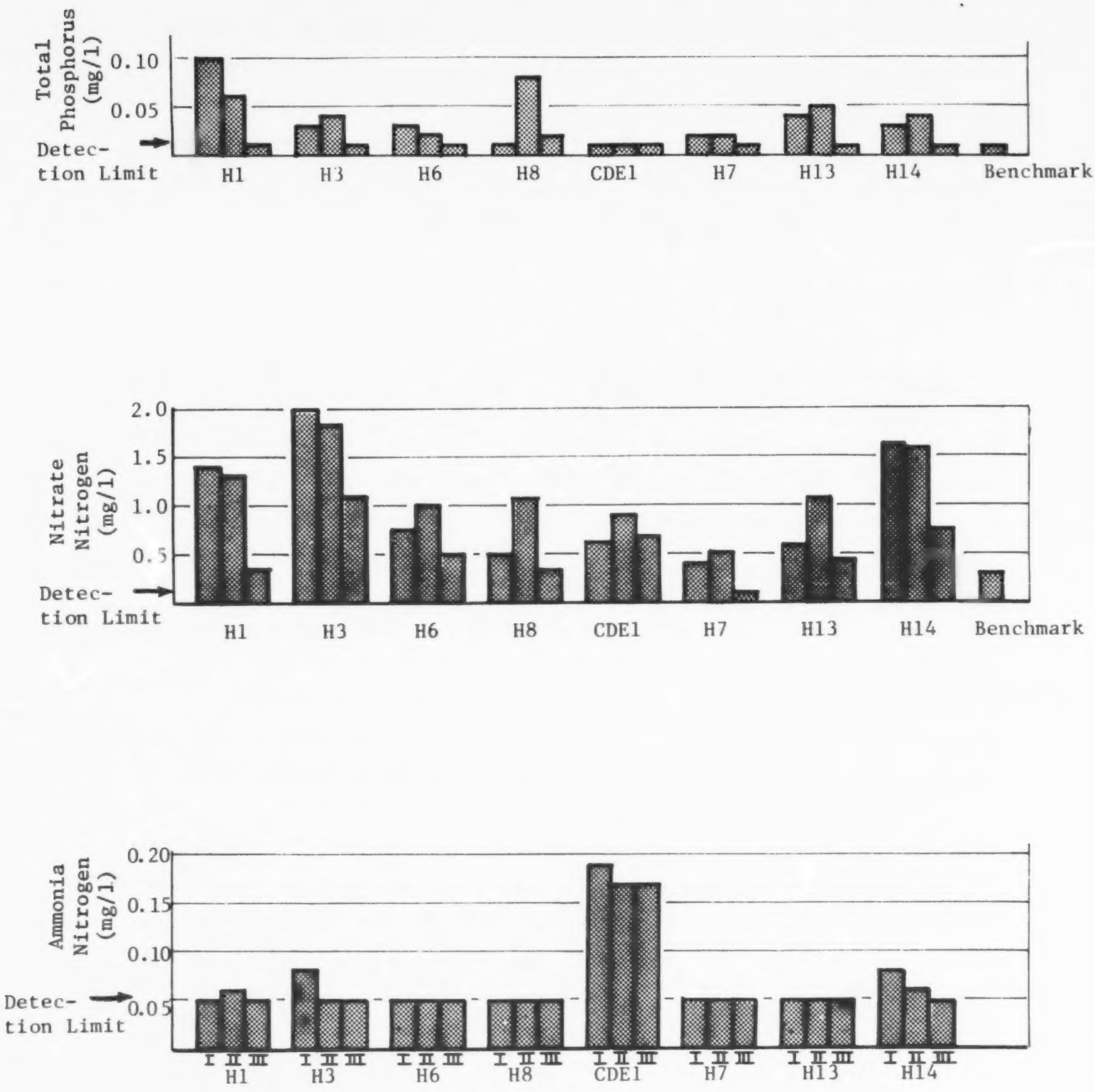

FIGURE 13. CONCENTRATIONS OF PLANT NUTRIENTS AT VARIOUS LOCATIONS IN CHERRY RUN WATERSHED

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

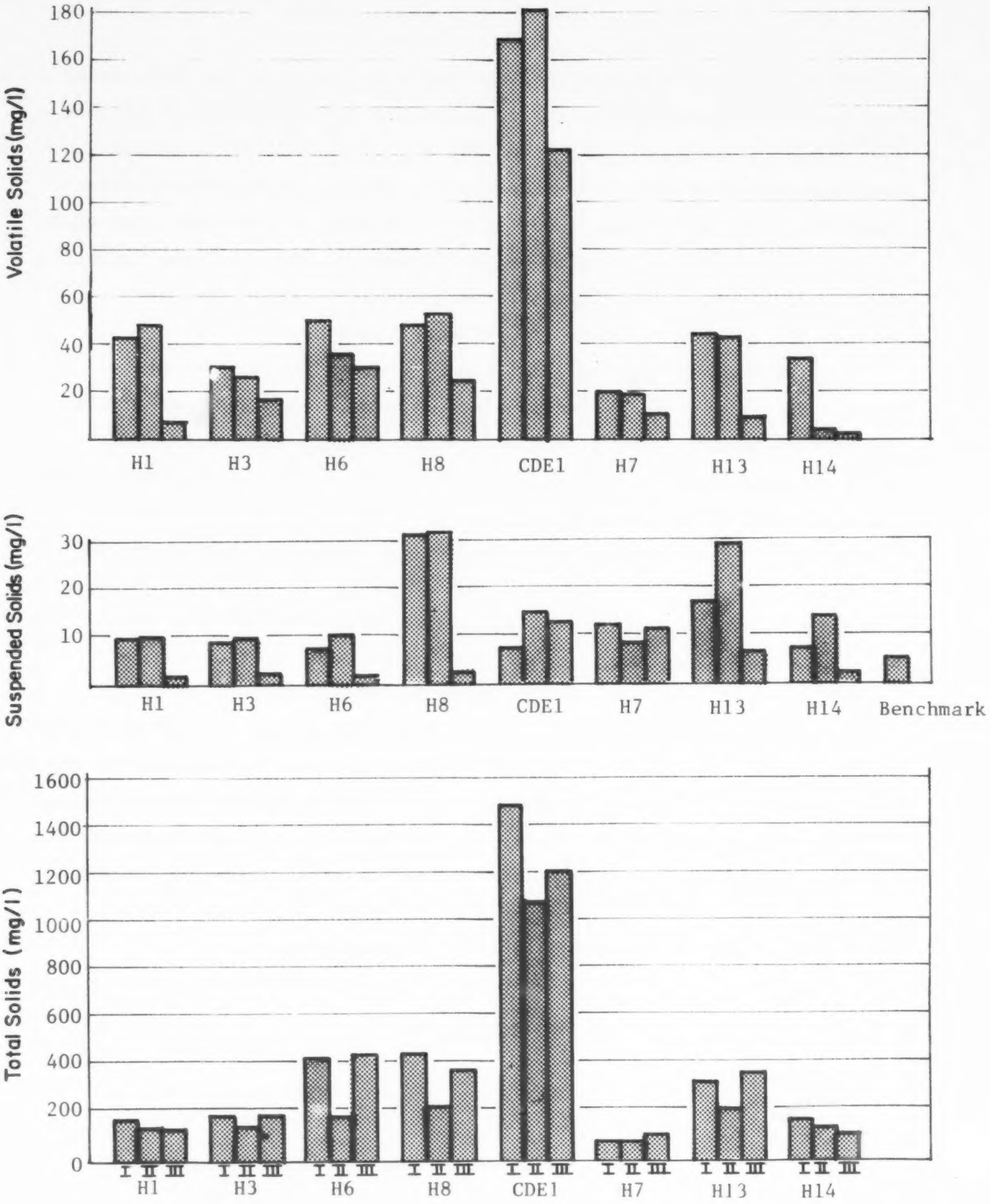

FIGURE 14. SOLIDS FRACTIONS AT VARIOUS LOCATIONS
IN THE CHERRY RUN WATERSHED

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

Nitrate levels were also influenced by agricultural and industrial land usage in the south tributary. Elevated concentrations of nitrate were found in drainage (CDE1) from the emergency holding ponds and in drainage (H6) from some small cornfields. Hence, downstream nitrate concentrations at H13 just prior to the discharge to the main stem were also elevated. Only during Campaign III did the nitrate value return to the baseline values as defined by the benchmark station, probably because of reduced transport from adjacent land uses.

Construction and agricultural runoff control the amounts of suspended and volatile solids in these streams. Although most of the fields have been contour plowed and strip-cropped, some erosion may still be occurring. At the site of construction for the leachate ponds, suspended solids increased significantly. Here and at the other stations, there was a notable decrease in suspended solids as the flow decreased. At CDE1 the suspended solids may be largely iron hydroxide precipitate, which would remain suspended longer than silt or sand. The high volatile solids may, in fact, have been the result of loss of hydration water, but this has not been verified.

The suspended solids in the south tributary do not settle until the juncture with the main stem at H14. Concentrations of suspended solids in the Cherry Run basin approached those in the reference stream during Campaign III. Total phosphate was quite low except at two locations-H1 and H8. Phosphate concentrations obtained at these sites are values probably associated with the solids fraction and were caused by agricultural and construction influences, respectively.

Wier's Run

Sampling locations for Wier's Run are shown in Figures 15 and 16.

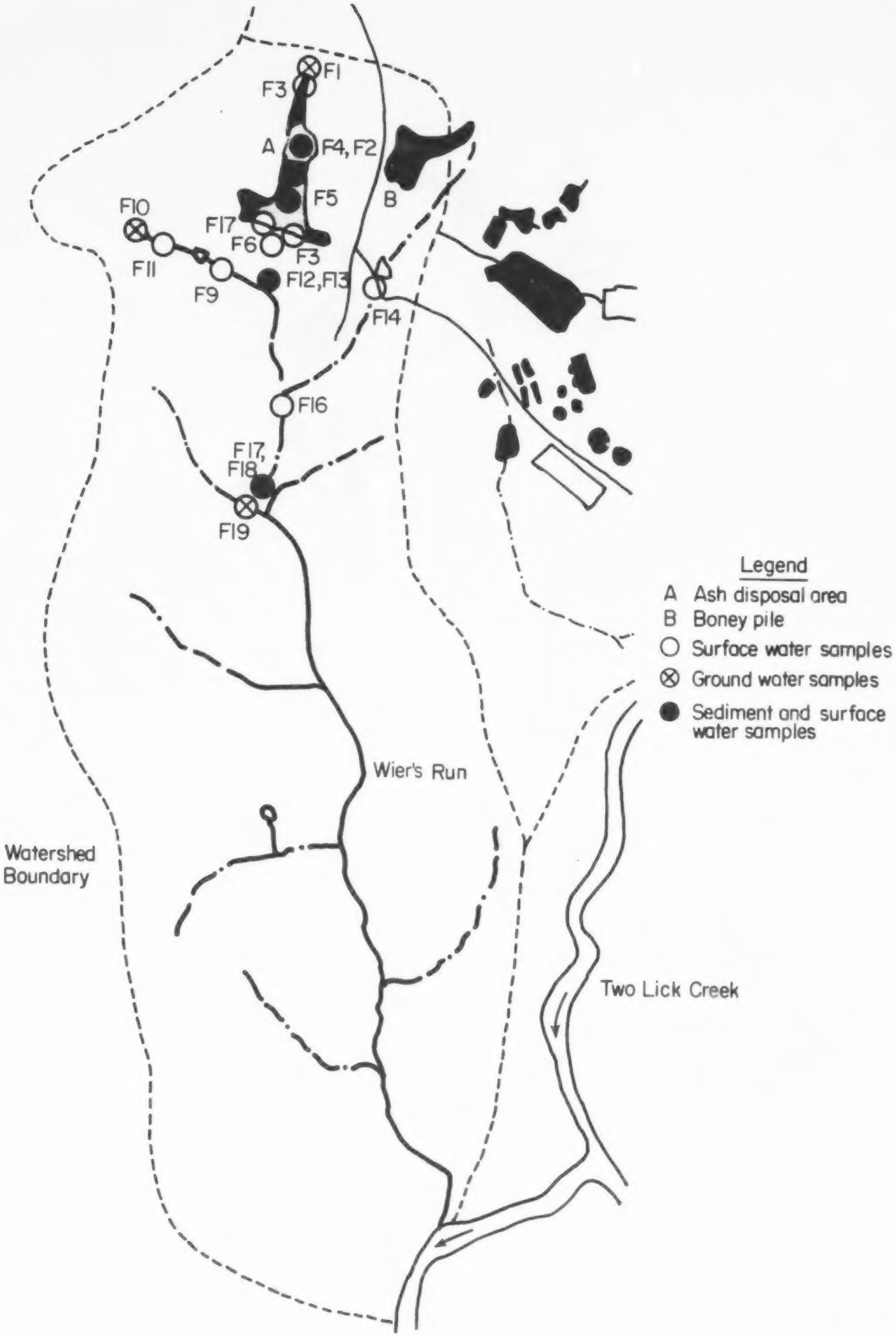
F1
F3
A
F4, F2
F5
B
F10
F17
F6
F3
F11
F9
F12, F13
F14
F16
F17,
F18
F19
Legend
A Ash disposal area
B Boney pile
○ Surface water samples
⊗ Ground water samples
● Sediment and surface water samples
Wier's Run
Watershed Boundary
Two Lick Creek

FIGURE 15. WIER'S RUN SAMPLING LOCATIONS--CAMPAIGN I

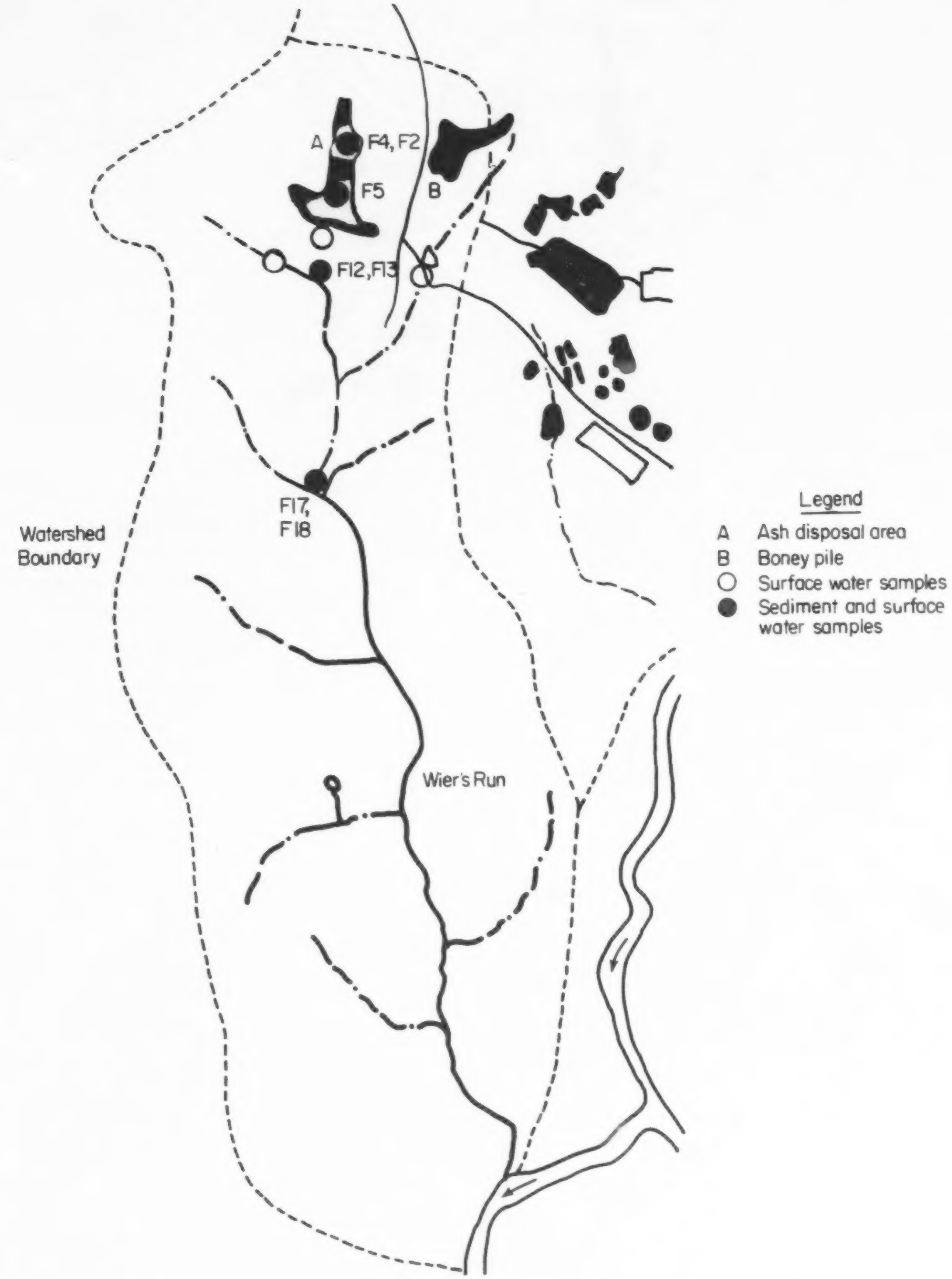
A
F4, F2
F5
B
F12, F13
F17,
F18
Watershed
Boundary
Wier's Run
Legend
A Ash disposal area
B Boney pile
○ Surface water samples
● Sediment and surface water samples

FIGURE 16. WIER'S RUN SAMPLING LOCATIONS--CAMPAIGNS II AND III

Solubility Controls

Reactions involving alkalinity, pH, and the solubility of iron, manganese, and calcium are again significant in relation to the control of leaching from the ash disposal area (Figure 17). As the percolate emerges below the ash dump, soda ash (Na_2CO_3) is added to artificially raise the alkalinity and pH. Water from these collectors and the untreated water from a small pond flows into large settling ponds.

The water quality just below the effluent weir showed that the iron was primarily in a soluble form. Also, ferrous iron constituted just over 10 percent of the total iron. As this effluent travels downstream and achieves equilibrium, most of the soluble iron should precipitate and the ferrous-ferric equilibrium should cause ferrous iron concentrations to fall below the detection limit. Manganese should precipitate farther downstream. In fact, this process was taking place and ferric and manganic hydroxides were found coating the stream bottom.

Just below the discharge point from the sedimentation ponds, a small tributary enters Wier's Run from the west. This tributary drains an area used for agriculture and cattle grazing. No activities relating to ash disposal or acid mine drainage occur in this subdrainage, and consequently low levels of iron, manganese, sulfates, and calcium were observed. No ferrous iron was detected. Alkalinity and pH were higher here but still well below the saturation for calcium carbonate. The volume of flow was small at the time of sampling and is annually intermittent.

About 0.4 mile downstream from the effluent weir, a tributary enters from the east. This stream was sampled upstream at a point where it exits from Oak Tree Pond. The inflow to Oak Tree Pond is a conduit which conveys the treated Helvetia Coal Company mine water discharged from the treatment pond indicated at point B on the site map (Figures 15 and 16). Lime is used to add alkalinity to the mine water and precipitate the iron. This treatment is generally successful as evidenced by

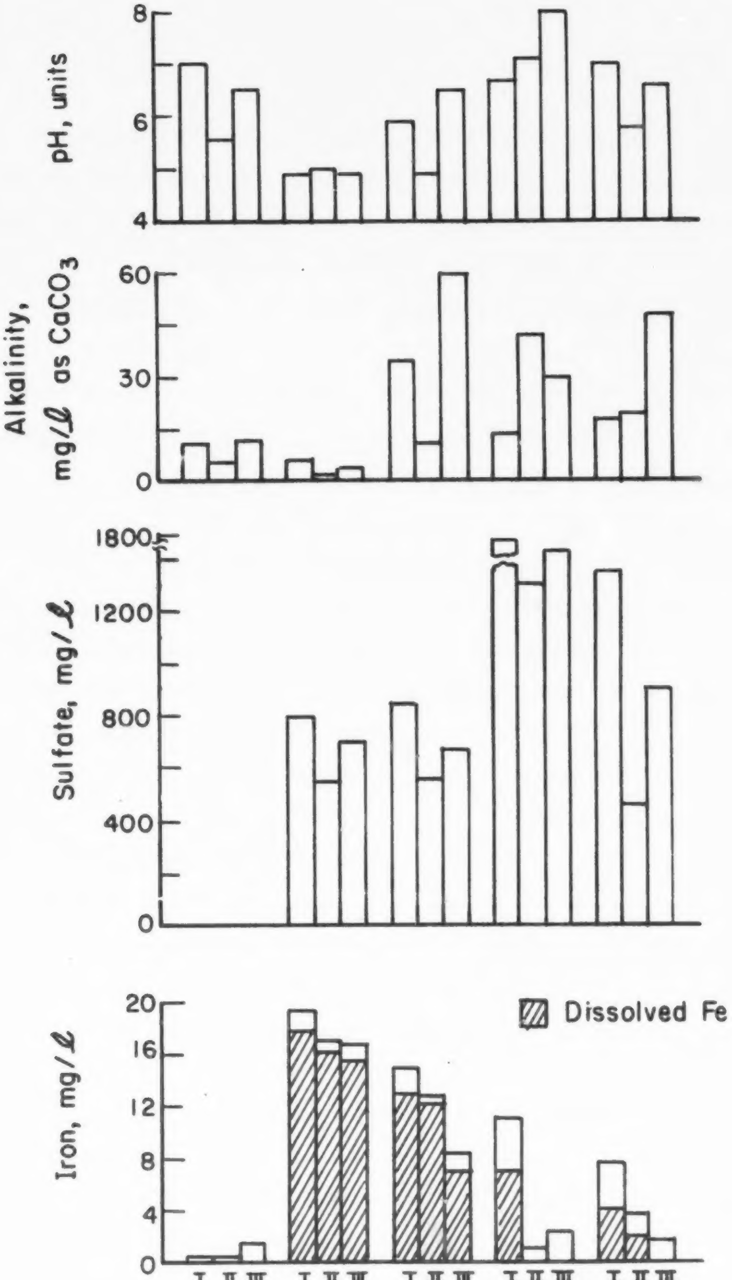

FIGURE 17. CONCENTRATIONS OF IMPORTANT SOLUBILITY-CONTROLLING SPECIES IN WIER'S RUN

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

the fairly low iron values; however, sulfates are not removed and calcium is added. This effluent was occasionally saturated with calcium sulfate, but very little precipitate is formed, probably because of the short hydraulic residence time.

At Site F17, the farthest downstream on Wier's Run, sulfates have been reduced only slightly. A layer of ferric hydroxide coats the bottom along this reach of stream and calcium carbonate is sometimes capable of being precipitated. Flow during Campaign III was measured at 3.1 cfs.

Buffer capacity in Wier's Run is very much a function of both the alkalinity and pH (Figure 18). At F12 below the ash-retaining dike, the alkalinity added by the Na_2CO_3 and the pH near the first ionization constant of carbonic acid buffers the water very effectively. At the downstream station, the pH changes and the buffer capacity drops.

Toxic Materials

As in Cherry Run Basin, the toxic materials concentrations were never very high. The most frequently detected metal was zinc, followed by nickel. Lead and cadmium were occasionally found but never at a discharge from a known metal source. Apparently, the metals are held very tightly in the ash matrix. Analysis of the ash showed high concentrations of sulfide, and this may provide the mechanism preventing the solubility of the metals.

The reason for the presence of arsenic in the water at Site F6 can only be speculated upon. This area is in the buffer zone for future expansion of the ash disposal facility and may have historically received coal refuse, or the spring flowing into the drain field may percolate through some thin coal lenses. Arsenic-containing herbicides may also have been used at one time.

Sediment samples were obtained at one location upstream and two locations downstream from the ash disposal facility (see Figures 15 and 16). The results of the analyses of these samples were somewhat

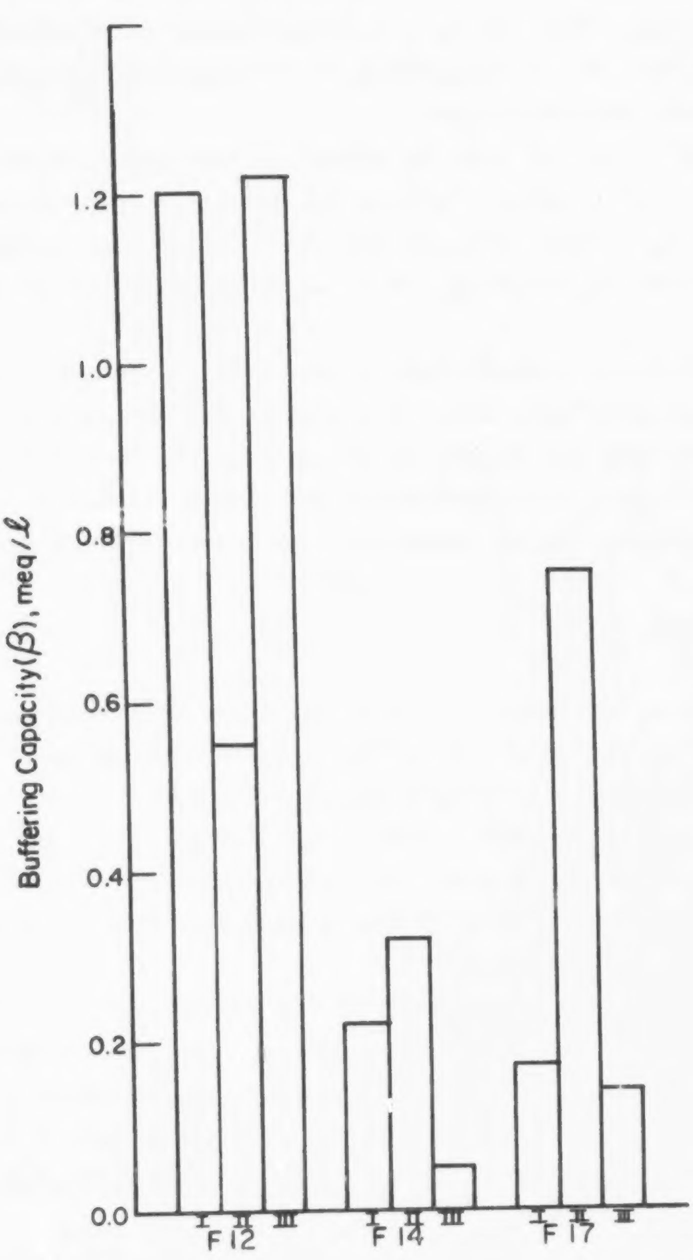

FIGURE 18. BUFFER CAPACITY--WIER'S RUN

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

surprising in view of the amounts of metals contained in the ash (Appendix C). For every toxic metal tested, the average concentrations in the sediments at F2 were greater than or equal to the concentrations at F13 and F18. However, inspection of the data on volatile solids coupled with sediment granulometry showed that the upstream sediment was a fine-grained organic material, which probably has several orders of magnitude more adsorption capability than the downstream sediments which were predominantly sands and gravel. The manganese and iron precipitates may also act as binding sites for metals, but there was not very much difference in iron content between the sites, so the differences between the upstream and downstream values for metals cannot be entirely explained on this basis.

Phenols, detectable at about half the stations, have no particular significance to the overall quality of the stream at these low concentrations.

Organic carbon loading and oxygen demand downstream from the ash disposal and Oak Tree Pond were too low to cause significant dissolved oxygen depletion. COD values were similar at F12 and F14 and somewhat higher than those at F17. TOC was less than 4 mg/l at all three locations and less than the detection limit (1 mg/l) at F12. The greatest departure from oxygen saturation occurred at Site F12 during the high flow of Campaign II. Dissolved oxygen dropped to 67 percent of saturation. Site F17 downstream was not affected. Dissolved oxygen there showed 94 percent saturation.

Nutrients and Solids

Total phosphorus, nitrate, nitrogen, and ammonia-nitrogen species are shown in Figure 19. Phosphorus was present in Wier's Run at high concentrations only in the small tributary below the ash disposal facility. As mentioned previously, this stream drains a cattle grazing and agricultural area. Samples from Sites F9 and F11 showed concentrations of 0.03 and 0.08 mg/l PO_4-P, respectively. As the volume of this flow was determined to be very small the steady-state quantity

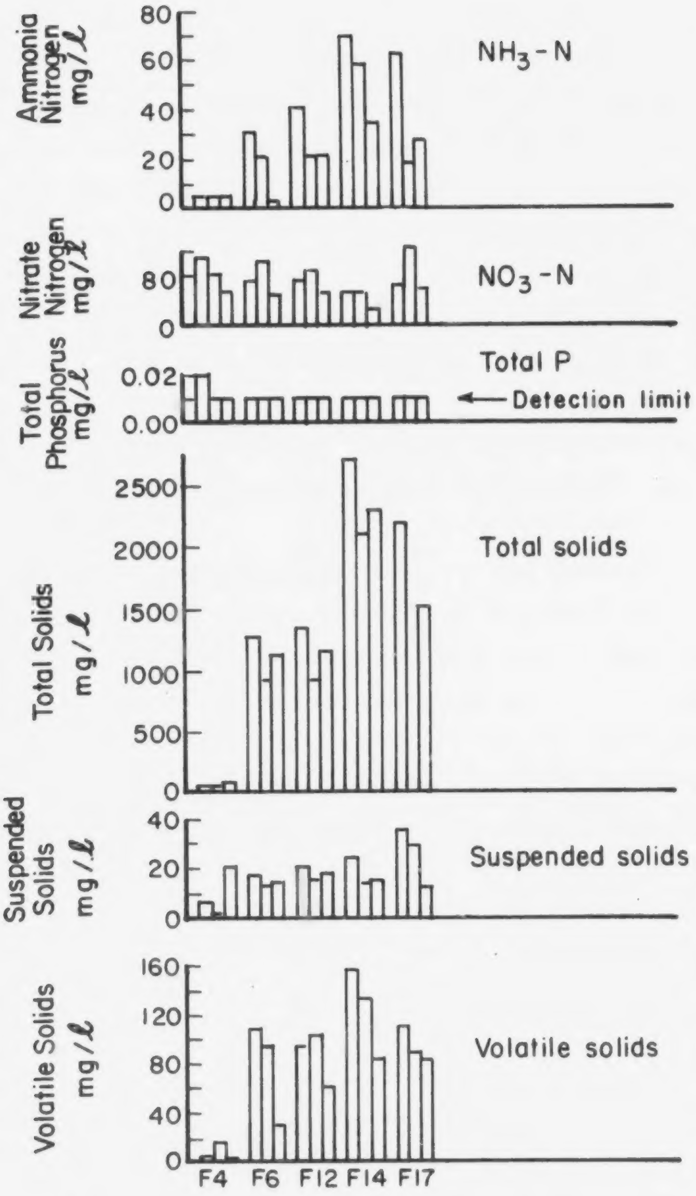

FIGURE 19. NUTRIENT CONCENTRATIONS IN WIER'S RUN BASIN

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

of phosphorus transported is also very small. It is likely that runoff samples would have shown much greater concentrations of phosphate.

Average nitrate concentrations were less than 1 mg/l NO_3-N. On the other hand, these concentrations are about three times those measured by the U.S.G.S. in the reference stream and show that nitrate is not being efficiently retained in the system. The highest concentrations were found during the first two campaigns. The weather during Campaign III was much drier than it was during the other two sampling periods, and this probably accounts for the differences.

Nitrate concentrations in drainage from the ash disposal area were slightly higher than those in the mine drainage effluent from Oak Tree Pond. The highest concentration of nitrate measured in this basin was 1.32 mg/l NO_3-N at Site F11.

Ammonia nitrogen shows a more interesting trend. The reducing environment (low Eh) in the ash dump and in the mine drainage water creates favorable conditions for the maintenance of ammonia in solution. The pH in these discharges from Oak Tree Pond and the ash dump is, however, not sufficiently high to allow a toxic concentration of unionized ammonia to exist. The water quality criterion of 0.02 mg/l NH_3-N as unionized NH_3 was never exceeded. Ammonia concentrations in Weir's Run were greater than those in Cherry Run.

The distribution of the solids fractions reflected the nature of the activities in Wier's Run (Figure 19). In absolute terms, the total solids sequence moving from upstream to downstream is dominated by the leaching of ions from the ash and the calcium and sulfate from the mine drainage. Both dissolved and total solids at F9 and F9 and F11 along the west tributary are less than 10 percent of the respective values at F12 and F14. Suspended solids also increase moving downstream, but not as significantly as the other solids fractions. The high suspended solids in the sample at F17 may be due to agricultural runoff. The suspended solids concentration at F11 was 185 mg/l. However, the presence of suspended iron and manganese oxides cannot be ruled out.

The percentage of total solids which is in the dissolved state ranges from 81 at the upstream site, F4, to 94 at the site farthest downstream, F17. It was not determined whether this difference is statistically significant. The portion of solids in the volatile (organic) fraction did not vary significantly as a function of location. Percentages ranged from 9.9 upstream to about 8 downstream. Samples from the intermediate sites, F12, F11, and F17, showed 7, 8, and 7 percent, respectively.

Common Ravine/Second Ravine

Sampling locations for Common Ravine/Second Ravine are shown in Figures 20 and 21.

Solubility Controls

The pH adjustment and lime coagulation of wastewater at the industrial treatment facility results in high alkalinity and pH precipitation of the iron and manganese, which is then settled and removed. However, discharge of effluent with this high pH and high alkalinity caused the calcium, manganese, and iron present in the water upstream from the industrial waste treatment facility to precipitate in the stream. The resulting mixture of calcium carbonate, ferric hydroxide, and manganic oxide or manganous carbonate settles to the bottom and in places is very much like a layer of concrete or plaster.

Chemical conditions in the stream were altogether different during the third campaign. The pH of the stream was acid and the alkalinity was zero. These conditions would tend to dissolve the calcium carbonate and probably some of the iron and manganese as well. Data are not available to determine whether these wide swings in pH are frequent and what their duration might be. This precipitation/resolubilization sequence represents a potential mechanism whereby heavy metals may be transferred between the liquid and solid phases and moved downstream.

The Second Ravine is also the receptor of several industrial wastes. Some of these are mining wastes and some are power plant wastes. The

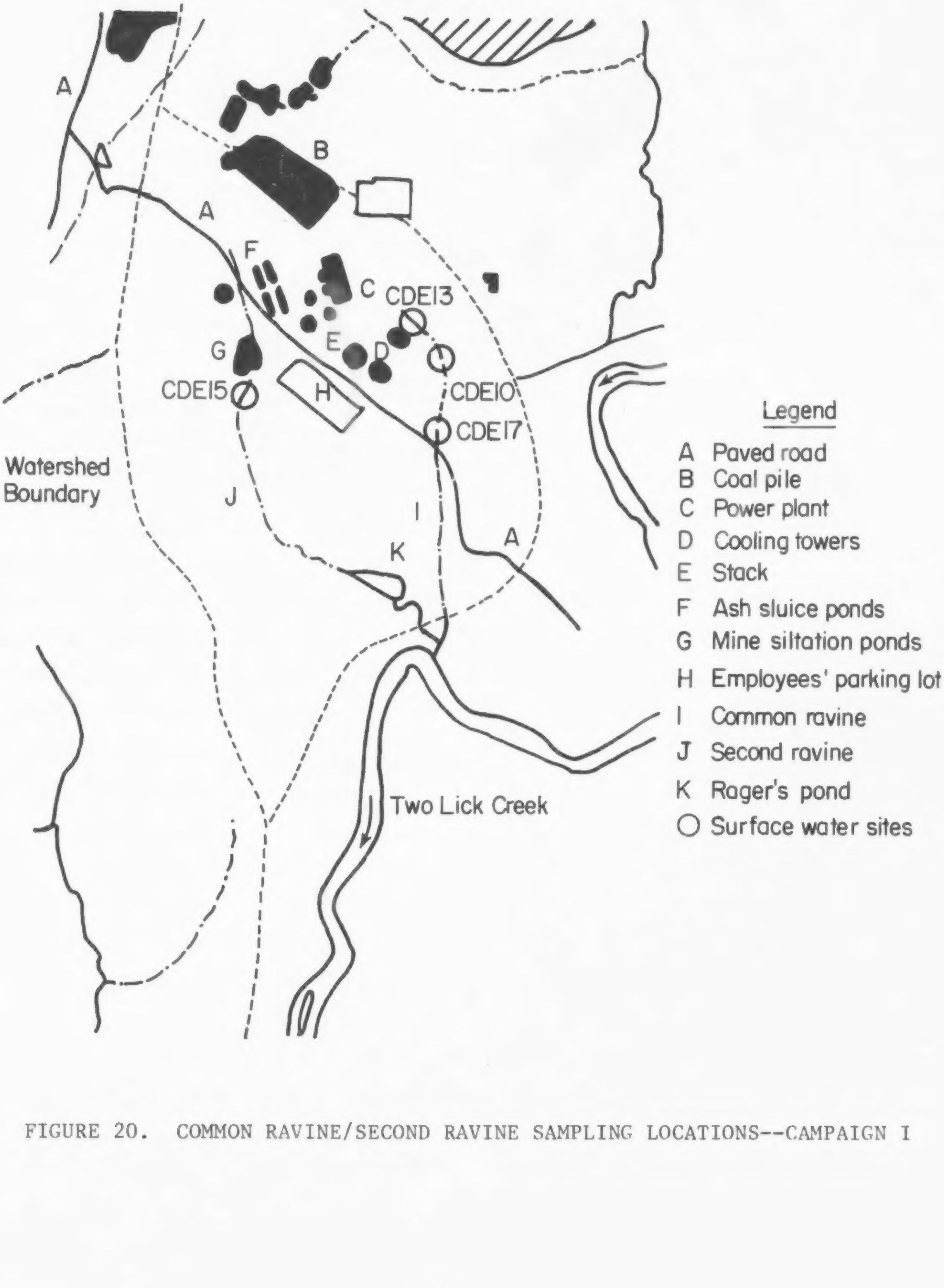
A
A
B
A
F
C
CDE13
G
E
D
H
CDE15
CDE10
CDE17
Watershed Boundary
J
I
A
K
Two Lick Creek
Legend
A Paved road
B Coal pile
C Power plant
D Cooling towers
E Stack
F Ash sluice ponds
G Mine siltation ponds
H Employees' parking lot
I Common ravine
J Second ravine
K Rager's pond
○ Surface water sites

FIGURE 20. COMMON RAVINE/SECOND RAVINE SAMPLING LOCATIONS--CAMPAIGN I

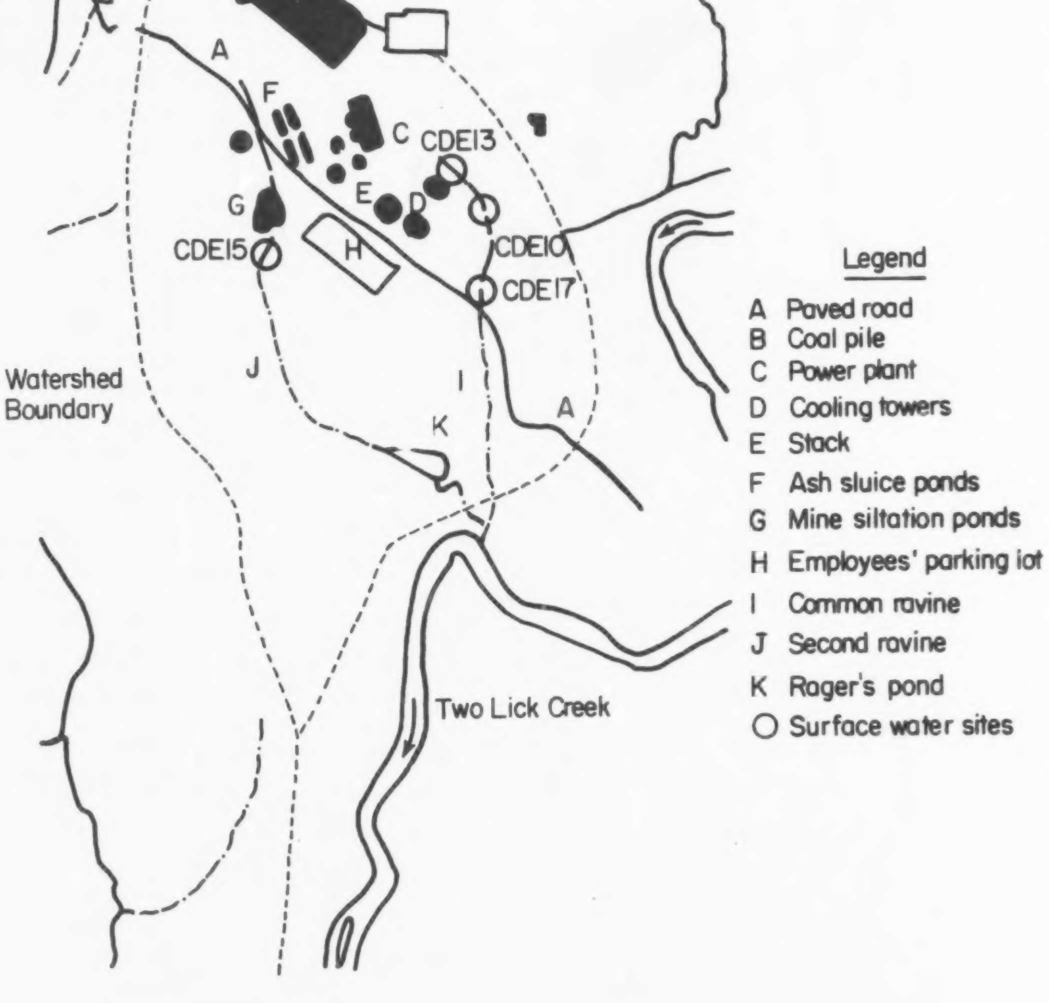
A
B
A
F
C
CDE13
G
E
D
H
CDE15
CDE10
CDE17
Watershed Boundary
J
I
K
A
Two Lick Creek
Legend
A Paved road
B Coal pile
C Power plant
D Cooling towers
E Stack
F Ash sluice ponds
G Mine siltation ponds
H Employees' parking lot
I Common ravine
J Second ravine
K Roger's pond
○ Surface water sites

FIGURE 21. COMMON RAVINE/SECOND RAVINE SAMPLING LOCATIONS--CAMPAIGNS II AND III

North American Coal Company has constructed an earthen dike across the ravine at a point adjacent to the Homer City Unit 3 stack. Boney coal is filled in behind the embankment and was the chief determinant of the chemical characteristics of the water. The overall quality of this water as it reached Site CDE15 was very similar to that of a partially oxidized and neutralized acid mine drainage (Class II) stream. Were it not for the alkaline pH overflow from the ash sluice ponds, Site CDE12, this water would probably be even more acidic and contain even higher levels of dissolved iron.

Overflow from the two coal-pile desilting basins is also discharged to this ravine, but flow was noted only during Campaign II. Even then the combined flow from both the round and rectangular basins was estimated at no more than 30 gpm (0.06 cfs) and would have contributed less than 2 percent of the flow measured at Site CDE15.

As leachate emerges from the boney pile, oxidizing conditions are established, and the ferrous iron which is stable and soluble to the extent of several hundred ppm in a low Eh system will oxidize to ferric iron. Site CDE16 is located downstream at the effluent end of Rager's Pond. By the time the ravine water reaches this point, the ferrous iron has had sufficient opportunity to oxidize and was no longer detectable.

It is further evident, however, that the ferric iron which was found has either not yet precipitated (as equilibrium conditions would require at this pH), or the precipitate which is formed is too fine to be trapped by the filter. Some visual evidence suggested that at least some of the iron was precipitating because the rocks and sticks covering the stream bottom were coated with the floc. In a number of samples at CDE15, calcium and manganese were also supersaturated with respect to the sulfate and the oxide.

The Common Ravine and Second Ravine join at a point about 0.2 km downstream from the outlet of Rager's Pond immediately before discharging into Two Lick Creek. No samples of this combined flow were obtained, but it is expected that because of the increased pH the precipitation process would be enhanced in the short reach of stream before it joins with Two Lick Creek.

Toxic Materials

Considering the volume and variety of trace metal- and phenol-containing materials handled at the electric generating station, it was not unusual for them to be present in the Common Ravine. Peak concentrations of the trace metals, as found in grab samples, were generally higher than the average concentrations in the composite samples. Phenolics showed the opposite trend from the heavy metals. Phenol concentration was higher by a factor of 10 to 15 in the composite samples than in the grab samples. Samples were composited by an ISCO automatic water sampler at the following rates: Campaign I, 90-minute intervals for 10 hours; Campaign II, 60-minute intervals for 10 hours; and Campaign III, 60-minute intervals for 30 hours.

Mercury and vanadium were found in the grab samples but not in the composite samples, while beryllium and hexavalent chromium were not found in any of the samples, grab or composite.

Oil and grease analyses were performed on a few samples. These confirmed the presence of fuel oil, as was suspected from the appearance and odor of samples taken from the Common Ravine. The source of this oil is unknown, as are the quantities being discharged. Whether this oil was contributing substantially to the trace metal and phenol concentrations observed is a matter of speculation. No. 2 fuel oil, as used for the start-up of the auxiliary boilers, is generally very clean in terms of trace metals. The phenol content of fuel oil is variable and dependent on the crude oil and the refining run.

The Second Ravine also had detectable concentrations of some heavy metals. Nickel and zinc occurred in the highest concentrations, as was the case in the other basins. Chromium, lead, mercury, and vanadium were not detected. The concentrations at the Rager's Pond site (CDE16) indicate a removal mechanism which is likely a combination of dilution and adsorption/coprecipitation with the iron. Solubility of discrete trace metal hydroxides should not be a major factor at the observed pH values. Only nickel and zinc were present in the outflow from the pond.

Phenolics were detected at the monitoring location immediately below the earthen dike in concentrations almost the same as those measured at

CDE17 on the Common Ravine. This correlation may not be a coincidence, because individual samples also had very similar concentrations. Reductions in phenol between the dike and Rager's Pond were even greater than those for zinc and nickel. Concentrations in the Second Ravine at Site CDE15 and in the Common Ravine at Site CDE17 were in excess of the 1976 water quality criterion of 0.2 mg/l.

Nutrients and Solids

The sanitary waste system for the power plant empties into the Common Ravine at a point above the industrial waste system discharge. The major portion of phosphate, nitrate, and ammonia were attributable to this source. Grab samples taken below the sanitary system and above the industrial system and those taken below both discharges were compared for NO_3-N, NH_3-N, total phosphate, and TOC. The ratios for the concentrations of these four nutrients in sanitary waste versus the combined waste were 1.12:1, 3.35:1, 1.66:1, 2.71:1, respectively. Sanitary waste, therefore, is the major contributor to the nutrient leads in the ravine. Phosphate removal would be expected in the lime coagulation system used at the industrial waste treatment facility.

Ammonia concentrations encountered at Site CDE17 would be considered toxic under normal stream quality circumstances. Concentrations of COD were as high as 231 mg/l (Campaign III), which would cause an oxygen reduction downstream but probably not before discharge to Two Lick Creek. Total organic carbon, suspended solids, and volatile solids concentrations were similarly high during Campaign III, suggesting a very large load of organic material. This loading cannot be totally attributed to the sewage treatment plant because the downstream concentrations of volatile solids and organic carbon in several instances were still substantial.

Two Lick Creek Basin

Sampling locations for Two Lick Creek are shown in Figures 22 and 23.

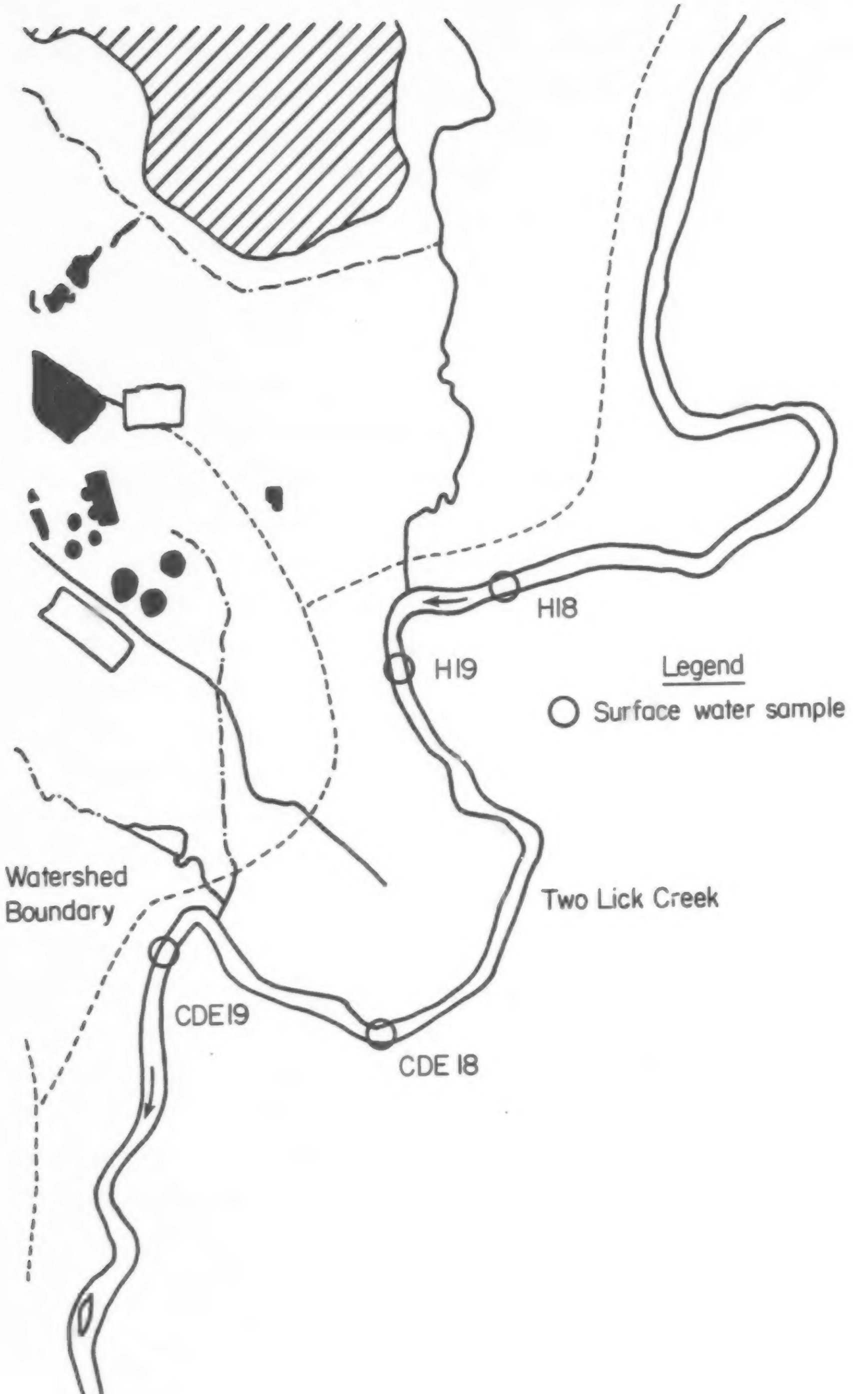
H18
H19
Legend
○ Surface water sample
Watershed Boundary
Two Lick Creek
CDE19
CDE 18

FIGURE 22. TWO LICK CREEK SAMPLING LOCATIONS--CAMPAIGN I

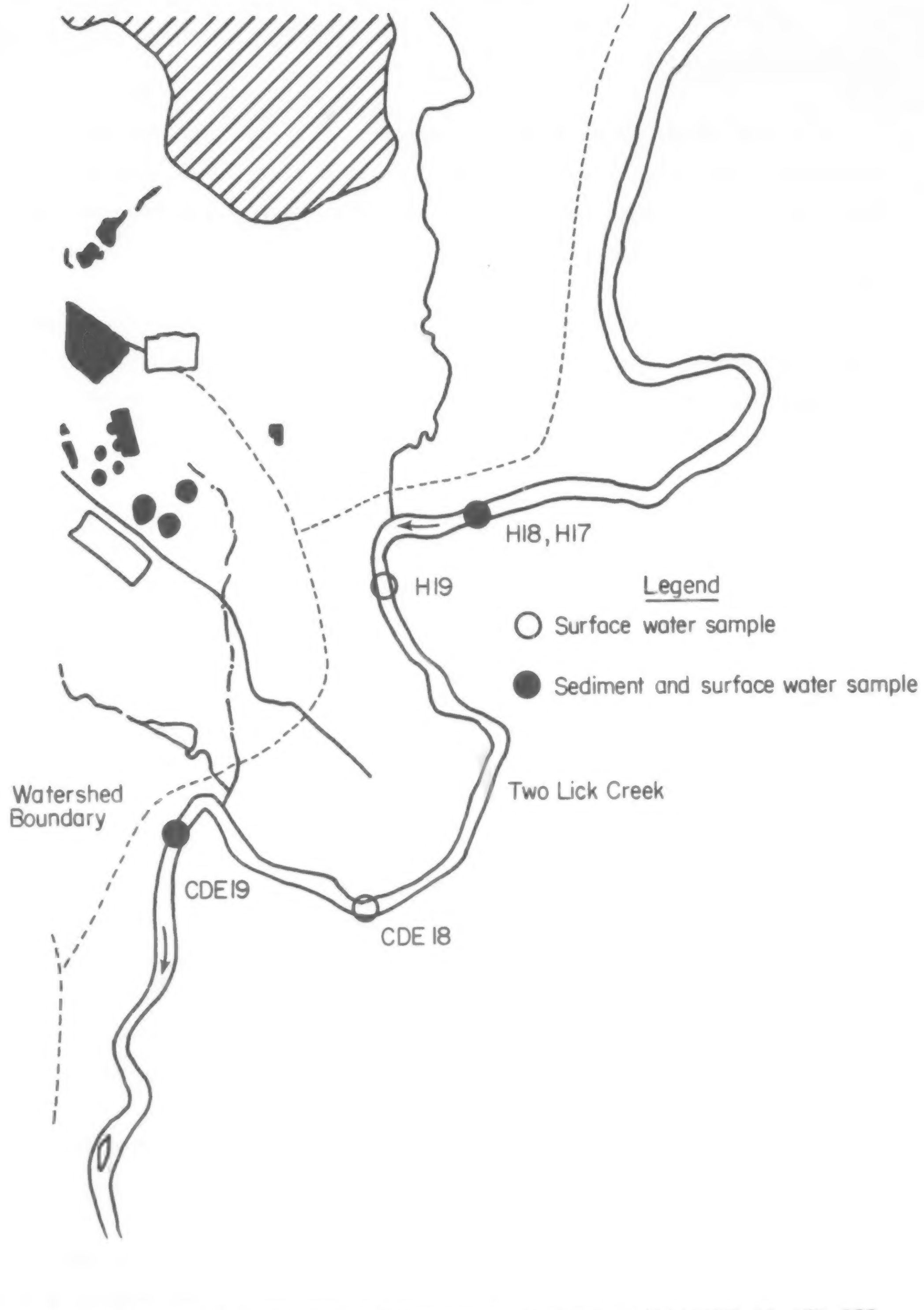
H18, H17
H19
Legend
○ Surface water sample
● Sediment and surface water sample
Two Lick Creek
Watershed Boundary
CDE19
CDE 18

FIGURE 23. TWO LICK CREEK SAMPLING LOCATIONS--CAMPAIGNS II AND III

Solubility Controls

Two Lick Creek is an acid mine drainage stream. The characteristics were typical for Class II partially neutralized and/or oxidized mine drainage (Figure 24). A number of strip mines are located upstream, which probably determines the overall quantity of iron, manganese, calcium, and sulfate in the water.

Concentrations of dissolved and ferrous iron in this stream were about as expected for the measured pH values from equilibrium calculations. Soluble calcium concentrations were not influenced by calcium solid phases at these low alkalinities and sulfate concentrations.

There are no significant differences between the upstream and downstream sample locations for pH, sulfate, iron species, manganese, calcium, and alkalinity. The differences noted between Sites H18 and H19 during Campaign I were attributable to day-to-day variation because these could not be sampled on the same day on this particular occasion. Compared with the values for the reference stream, Two Lick Creek bears almost no resemblance to undeveloped, pristine conditions.

Toxic Materials

The water in Two Lick Creek is relatively free of heavy metals. Zinc was the only metal detected with consistency. Sediment analyses were extremely limited but indicated much the same metal accumulations as the sediments in the rest of the region. Mercury and lead were somewhat higher in these samples than in those from the remainder of the basins, and may be attributable to upstream land uses which include urban and industrial classifications.

One attribute which these sediments possessed to a greater degree than the others was a very high organic content and a high percentage of particles in the fine sand to clay range.

The high organic content also resulted in the creation of low-Eh (reducing) conditions in the sediment. The visual appearance of the

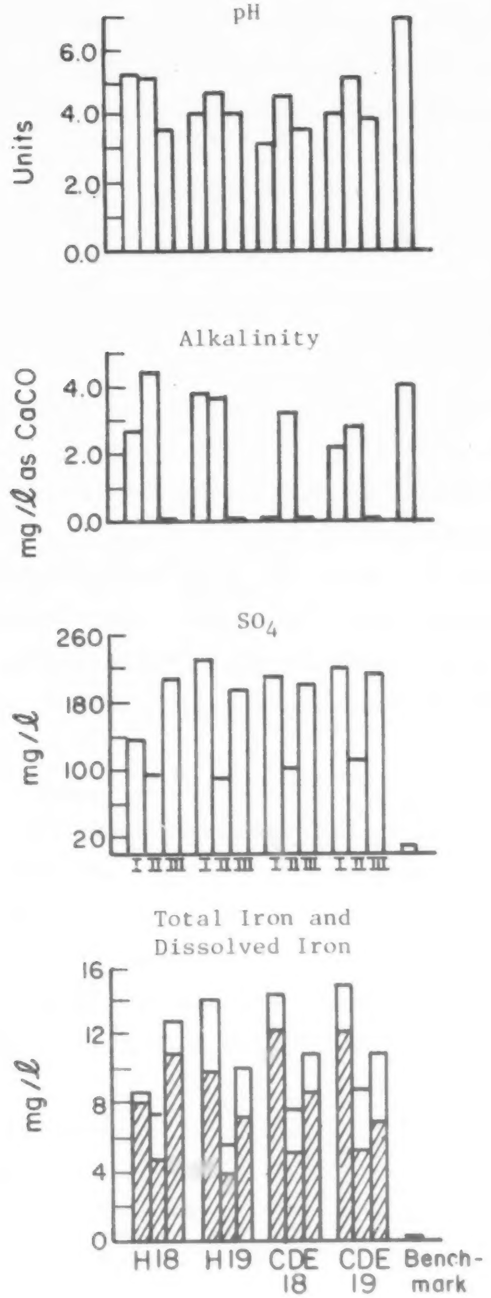

FIGURE 24. CONCENTRATIONS OF SOME IMPORTANT SOLUBILITY CONTROLLING SPECIES IN TWO LICK CREEK

Note: I = Campaign I, II = Campaign II, and III = Campaign III in all histograms shown above the Roman numerals.

sediments and the chemical analysis confirmed the presence of sulfide. This is likely to be the solid phase controlling the soluble metals in the sediments. Iron, mercury, cadmium, lead, and zinc all form extremely insoluble sulfides.

Phenolics were detected only sporadically and at concentrations that were not significant to stream quality.

Nutrients and Solids

Of the nutrient fractions, only nitrate exhibited a significant upstream-downstream increase, especially at Cherry Run. Values obtained for samples from Site H18 were similar to the benchmark station but increased to several times that downstream.

Ammonia, if anything, shows the opposite trend of nitrate being diluted by the discharge from Cherry Run. There is no difference between the concentrations upstream and downstream from the ravine discharge. At these pH values, the ammonia concentrations observed are not toxic.

Phosphate concentrations were low in most samples.

Suspended solids concentrations ranged from 1 to 7 times the concentrations in samples from the benchmark station. Considering the amount of agriculture and pasturing activity that takes place between the discharge points from Cherry Run to Homer City itself, it is somewhat surprising that the amounts were not even higher. In any case there was no upstream/downstream trend either to increase or to decrease.

The percentage of total solids which are suspended ranged from 4 to 13 and the percentage of total solids which are volatile was occasionally as high as 20, attesting to the heavy loading. Dissolved solids were primarily sulfates and cations from mine drainage. There was no statistical variation between the upstream and downstream values for total or volatile solids.

Summary of Water Quality Conditions

The results of the three sets of water quality data obtained at Homer City during the winter and spring of 1976-1977 indicate the following:

- Water quality in most basins reflects the degree of human activity in the region. This is especially apparent for the Common and Second Ravines, Two Lick Creek, and Wier's Run below the ash disposal area.
- The flows which exhibited water quality closest to that of the reference stream were the discharges from the springs to the south tributary to Cherry Run, followed by the west tributary to Wier's Run and the north tributary to Cherry Run.
- The main channel and north tributary of Cherry Run are influenced to some degree by neutralized and diluted drainage from mines or a similar source and by agricultural or pasture-land drainage.
- The south tributary of Cherry Run is affected by flow from the settling ponds below the coal preparation plant from the standpoint of solubility controls, metals, and ammonia. These effects are localized and do not extend into the main channel.
- The primary impact of the construction of the sediment and leachate collection ponds was the increase in the suspended solids levels downstream. Some increases in nutrients were also noted.
- Sulfates concentrations are already high in the south tributary to Cherry Run before it reaches the upstream monitoring location. The source has not been identified.
- Water quality in Wier's Run is determined by two factors--the migration of rain water through the ash, and the lime treatment given to the drainage from Helvetia Mine. Levels of major ions and trace metals are set by these processes. In-stream chemistry determines the fate of the metals.

- The agricultural drainage from the west tributary and the mine drainage contribute most to the observed organic loads. Agricultural drainage also contributes to the suspended solids and nutrients loads.
- The ravines are receptors for industrial wastes, and this water reflects power plant operations and mining activity.
- Water in the Common Ravine contains both nutrients and metals. Industrial waste treatment provides a mechanism for in-stream precipitation of metals.
- Water quality in Two Lick Creek is determined by the amount of acid mine drainage created upstream. Project area influences were seldom noted as being significant.

Comparison of Analytical Data with MEG Values--Aquatic Environment

Stream Water Concentrations versus MEG Values

Maximum and minimum concentrations of 15 elements that were analyzed in surface water are compared with the appropriate MATE and EPC values for the environment in Table 9. These data were organized to correspond to the biological sampling locations for additional comparisons. Although data were obtained in the study area near Homer City for 30 different parameters used to define water quality in stream water, MEG values are available for only the parameters listed in Table 9.

EPC and MATE values suggested for the environment were exceeded by many of the maximum and minimum values determined for the 15 water quality parameters listed in Table 9. Maximum values for 9 parameters measured in surface water throughout the study area exceeded the corresponding MATE values, and maximum values for 11 parameters exceeded the corresponding EPC values. Maximum and minimum values of measured parameters exceeded EPC's in the following 10 cases: beryllium, lead,

TABLE 9. COMPARISONS OF EPC AND MATE VALUES FOR WATER WITH HOMER CITY SURFACE WATER QUALITY DATA[(a)]

MEG Category and Substance	Minimum Acute Toxicity Effluent (MATE) for Ecology	Estimated Permissible Concentration (EPC) for Ecology	Streams in the Vicinity of Homer City Station: Cherry Run: Main Stem		North Tributary to Cherry Run		South Tributary to Cherry Run: Upstream		South Tributary to Cherry Run: Downstream		Wier's Run Below Ash Disposal Area		Tributary to Wier's Run		Rager's Pond Tributary		Common Ravine		Two Lick Creek		Reference Stream Dec-Apr Average[(e)]
			Water Quality Evaluation[(b)]																		
			Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
18 Phenolics	500	100[(d)]	--[(c)]	--	--	--	--	--	--	--	10	ND	7	6	340	9	360	30	8	ND	--
32 Beryllium	55	11[(d)]	ND[(f)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	20	20	ND	ND	ND	ND	--
34 Calcium	16,000	--	23,600	16,500	20,300	17,400	38,900	19,200	37,200	7,200	208,500	86,000	--	--	209,000	113,000	485,000	102,500	43,900	21,000	3,500
46 Lead	50	10[(b)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	20	ND	ND	1
47 Ammonia Nitrogen	50	10[(d)]	80	<50	60	<50	50	<50	<50	<50	630	180	--	--	14,400	360	4,200	1,600	1,280	190	--
49 Arsenic	50	10[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	8	ND	ND	ND	20	ND	60	20	ND	ND	<1
65 Vanadium	150	75[(d)]	ND	ND	ND	ND	300	ND	ND	ND	ND	ND	--	--	ND	ND	ND	ND	ND	ND	--
68 Chromium	250	50[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	40	20	ND	ND	<10
68 Chromium^{+6}	250	50[(d)]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	ND	ND	--
71 Manganese	100	20[(d)]	460	20	280	20	210	130	1,400	<20	6,100	1,400	--	--	45,200	2,210	1,760	680	1,300	550	20
76 Nickel	10	2[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	100	70	ND	ND	640	80	140	60	ND	ND	--
78 Copper	50	10[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	60	ND	50	30	ND	ND	0
81 Zinc	100	20[(d)]	20	ND	20	20	50	50	50	30	120	90	40	ND	1,730	100	290	230	110	80	0
82 Cadmium	1	0.4[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	3	2	ND	ND	0
83 Mercury	250	50[(d)]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.5
			Biological Quality Evaluation[(g)]																		
Attached Algae			F		F		F		P		F		G		P		P		P		
Bottom-Dwelling Invertebrates			P		G		G		P		P		G		P		P		P		
Fish			F		G		G		P		P		G		P		P		P		
Overall Rating			F		G		G		P		P		G		P		P		P		

(a) All values are given in μg/l; EPC and MATE values are from Cleland and Kingsbury (1977a and b).
(b) Data from three sampling campaigns conducted by Battelle in the study area.
(c) Data not available.
(d) Based on most stringent existing or proposed Federal standard for water quality (Cleland and Kingsbury, 1977a and b).
(e) Chemical analysis during water year 1973 of Young Women's Creek near Renovo, Pennsylvania (U.S. Department of the Interior, 1974).
(f) ND = not detectable.
(g) The aquatic biota evaluations are based on standing crop, species diversity, and presence of indicator species or families;
G = good; F = fair; and P = poor aquatic biota quality. Data are from two sampling campaigns conducted by Battelle in the study area.

Note: For ease of making comparisons, EPC and MATE values which are used for making comparisons and the field data which exceed them are underlined.

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ammonia, nitrogen, arsenic, manganese, nickel, copper, zinc, and cadmium.

Streams considered to have good biological quality also had levels of pollutants which exceeded EPC or MATE values for the environment. Maximum and minimum levels of manganese and zinc in streams with good aquatic biota quality exceeded the EPC values for the environment. Maximum levels, alone, of two additional parameters (ammonia and vanadium) in streams with good aquatic biota quality also exceeded the EPC values for the environment. Similarly, maximum and minimum levels of calcium and manganese in streams with a good biological quality rating exceeded the MATE values for the environment.

Stream Water Concentrations versus Recommended Values

MEG values have not yet been determined for 14 of the 30 water quality parameters measured in Battelle's study area. Therefore, comparisons have been made between these 14 parameters and eight values recommended by the EPA (1976) or suggested by McKee and Wolfe (1963) (see Table 10). A biological quality evaluation of the same stream stretches that were analyzed for water quality is presented for comparison with the chemical data.

All eight of the water quality criteria concentrations recommended by EPA (1976) or McKee and Wolf (1963) were exceeded by one or more concentrations of the same parameters measured in samples from streams in the study area (Table 10). The maximum and minimum values for alkalinity, sulfate, and total solids observed in one of the streams with a good biological quality rating were greater than the recommended criteria concentrations.

A comparison of the data for each of the 30 surface water quality parameters with the biological quality evaluation for the same stream segment suggests that values for four parameters agree closely with the biological quality rating (Tables 9 and 10). The maximum and minimum values for these four parameters (pH, suspended solids, dissolved iron, and total organic carbon) have been compared with recommended or

TABLE 10. COMPARISONS OF CRITERIA RECOMMENDED FOR FRESHWATER AQUATIC LIFE WITH HOMER CITY SURFACE WATER QUALITY DATA(a)

Water Quality Parameter	Recommended Criteria: Freshwater Aquatic Life		Streams in the Vicinity of Homer City Station																		Reference Stream Dec-Apr Average(d)
	EPA(b)	McKee & Wolf(c)	1. Cherry Run: Main Stem		2. North Tributary To Cherry Run		South Tributary To Cherry Run: 3. Upstream		South Tributary To Cherry Run: 4. Downstream		5. Wier's Run Below Ash Disposal Area		Tributary To Wier's Run		6. Rager's Pond Tributary		7. Common Ravine		8. Two Lick Creek		
			Water Quality Evaluation																		
			Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
			Solubility Controls(f)																		
Acidity, as $CaCO_3$	--(e)	--	7,800	1,400	7,200	1,400	1,800	1,400	4,300	1,400	45,700	3,100	--		1,999,000	28,300	183,000	0	79,000	31,400	--
Alkalinity, as $CaCO_3$	>20,000	--	44,200	13,200	44,200	21,100	19,600	12,600	15,700	7,100	60,100	11,000	--		2,400	0	615,000	0	4,900	0	3,800
pH	9.0-6.5	9.0-6.3	7.2	6.1	7.6	6.7	7.9	6.6	7.5	6.4	7.6	4.9	--		4.9	4.3	11.4	4.8	5.3	3.2	6.9-6.2
Total Fe	1,000	200	1,990	140	1,710	140	530	80	660	200	15,000	1,820	--		472,500	8,000	21,400	7,930	15,000	5,670	20,000
Dissolved Fe	--	--	760	<20	10	<20	90	<20	60	<20	13,000	20	--		453,000	7,900	8,200	20	12,400	3,930	--
Fe^{2+}	--	--	760	<100	420	<100	190	<100	170	<100	2,140	<100	--		467,000	<100	370	<100	6,030	<100	--
Sulfate (SO_4)	--	11,000	83,600	27,300	37,500	27,300	267,000	115,000	204,000	20,600	1,360,000	460,000	--		2,940,000	424,000	1,180,000	290,000	230,000	90,000	7,[illegible]
			Nutrients and Solids(f)																		
Total Phosphorus	100	--	40	<10	100	10	30	10	50	10	10	<10	--		<10	<10	160	<10	170	<10	10
Suspended Solids	--	30,000	14,000	2,000	10,000	1,200	10,800	1,200	29,800	6,800	35,300	11,200	--		136,000	21,600	968,000	61,250	34,500	5,600	5,000
Volatile Solids	--	--	34,000	2,000	48,000	7,000	50,000	30,000	45,000	5,000	115,000	60,000	--		738,500	830	1,046,000	2,580	76,000	24,000	--
Nitrate - N	90,000	--	2,000	760	1,420	360	1,000	500	1,070	<100	1,260	520	--		4,400	2,060	3,750	400	1,800	220	ND(i)
Total Kjeldahl - N	--	--	360	140	340	<50	270	120	160	<50	950	270	--		17,800	500	4,550	2,200	1,250	350	--
Total Organic Carbon	--	--	4,000	1,700	2,000	1,200	3,500	1,300	4,000	1,200	7,000	<1,000	--		24,800	3,000	97,500	7,250	6,500	1,800	ND
Total Solids	--	102,000(g)	183,000	124,000	159,000	124,000	442,000	180,000	380,000	82,000	2,119,000	818,000	--		4,978,500	743,000	2,260,500	579,500	438,000	205,000	
Dissolved Solids	--	--	No Data From Homer City																		26,000
			Biological Quality Evaluation(f,h)																		
Attached Algae			F		F		F		P		F		G		P		P		P		
Bottom-Dwelling Invertebrates			P		G		G		P		P		G		P		P		P		
Fish			F		G		G		P		P		G		P		P		P		
Overall Rating			F		G		G		P		P		G		P		P		P		

(a) All values are given in µg/l except pH units.
(b) "Quality Criteria for Water" (EPA, 1976).
(c) "Water Quality Criteria" (McKee and Wolf, 1963).
(d) Chemical analysis during water year 1973 of Young Women's Creek near Renovo, Pennsylvania (U.S. Department of the Interior, 1974).
(e) Not available.
(f) Data from three sampling campaigns conducted by Battelle in the study area.
(g) Estimated by summing the values recommended for suspended and dissolved solids.
(h) The aquatic biota evaluations are based on standing crop, species diversity, and presence of indicator species or families; G = good; F = fair; and P = poor aquatic biota quality. Data are from two sampling campaigns conducted by Battelle in the study.
(i) ND = not detectable.

Note: For ease of making comparisons, recommended criteria which are used for making comparisons and the field data which exceed them are underlined.

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suggested water quality criteria in Table 11. It can be seen that streams with good biological quality did not have any levels of these four parameters which were above the recommended criteria. Maximum, and frequently minimum, values of these four parameters, however, exceeded the recommended criteria in streams with poor biological quality. The significance of these four "master" parameters to aquatic biota is probably great because they affect the presence of other potentially toxic water pollutants.

Several studies have described the effects of water pollutants in acid mine drainage on aquatic biota. These studies found that the master chemical factors involved one or more of the parameters listed in

TABLE 11. WATER QUALITY PARAMETERS IN CLOSE AGREEMENT WITH BIOTA QUALITY RATING

Water Quality Parameter	Sampling Sites(a) (units or concentrations>specified value(b))							
	1	2	3	4	5	6	7	8
pH (6.5-9.0)(c)	1	0	0	1	1	2	2	2
Suspended Solids (20,000 μg/l)(d)	0	0	0	1	1	2	2	1
Dissolved Fe (1,000 μg/l)(d)	0	0	0	0	1	2	1	2
Total Organic Carbon (4,000 μg/l)(d)	1	0	0	1	1	1	2	1
Grand Totals	2	0	0	3	4	7	7	6
Biota Quality Rating(e)	F	G	G	P	P	P	P	P

(a) Sampling site locations correspond to the eight locations listed at the top of Table 10.

(b) Maximum and minimum units or concentrations<specified value = 0; maximum units or concentrations>specified value = 1; maximum and minimum units or concentrations>specified value = 2.

(c) Criteria recommended by EPA (1976). Maximum and minimum pH within recommended range = 0; maximum or minimum pH outside recommended range = 1; maximum and minimum pH outside recommended range = 2.

(d) Criteria suggested on the basis of the chemical and biological data presented in this paper.

(e) G = good; F = fair; P = poor quality.

Table 11. Weed and Rutschky (1972), for example, found that pH, alkalinity, and ionic concentrations of iron and sulfate were primarily responsible for altering the community structure and diversity of benthic macroinvertebrates. Similarly, Warner (1971) found that pH measurements in streams seemed to provide the most reliable, as well as unique, index of the effects of acid mine drainage on aquatic life. A report by the Federal Water Pollution Control Administration (1969) concluded that acid mine drainage damages aquatic biota primarily because of the high concentrations of mineral acids, the ions of iron, sulfate, and the deposition of a smothering blanket of precipitated iron salts on the stream bed.

Sediment Concentrations Versus MEG Values

The maximum and minimum concentrations for eight of nine trace metals (lead, arsenic, chromium, manganese, nickel, copper, zinc, cadmium, and mercury) measured in stream sediments exceeded their corresponding EPC values (Table 12). Comparisons of concentrations for the same nine elements in fly ash from the ash disposal area revealed that maximum and minimum ash concentrations of six elements exceeded their associated MATE and EPC values. Maximum and minimum concentrations of all of these elements, except chromium, mercury, and cadmium, were higher in separate grab-sample analyses of the three raw coals used in the Homer City power complex than they were in the associated MATE or EPC values. Therefore, coal and fly ash from a variety of sources may be contributing to the trace element content in the sediments of the study area streams.

In spite of the toxic trace elements in its sediments, one stream in the study area still had a good biological rating (Table 12). The upstream portion of the south tributary to Cherry Run had good biological quality. This stream, however, had maximum and minimum concentrations of seven elements (lead, chromium, manganese, nickel, copper, zinc and cadmium) that exceeded the associated MATE and EPC values.

TABLE 12. COMPARISONS OF EPC AND MATE VALUES FOR SOIL WITH HOMER CITY SEDIMENT QUALITY DATA

MEG Category and Substance	MATE(b) for Ecology	EPC(b) for Ecology	Streams in the Vicinity of Homer City Station								Ash Analysis(e)		Analysis of Three Raw Coals(f)	
			Cherry Run: Main Stem		Upstream On South Tributary To Cherry Run		Wier's Run Below Ash Disposal Area		Two Lick Creek		Max.	Min.	Max.	Min.
			Concentrations in Stream Sediments(c)											
			Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.				
46 Lead	10	3(d)	50	19	63	36	29	2	85	48	14	12	17.8	12.3
49 Arsenic	10	2	15	4.8	9.6	6.6	19	7.6	21.5	10	5.4	3.8	49	23
68 Chromium	50	10	346	84	225	157	197	102	152.5	90	144	112	36	31
71 Manganese	20	4	2,830	248	1,430	612	1,000	349	251.5	210	--(h)		76	36
76 Nickel	2	0.4	207	71	130	115	117	71	79	33	75	71	17.5	13.2
78 Copper	10	20	440	23	310	120	270	25	230	94	126	90	32	21
81 Zinc	20	4	387	75	677	244	210	65	207	108	73	40	69	47
82 Cadmium	0.2	0.01(d)	1.0	0.5	1.0	0.5	0.4	0.2	0.55	0.55	0.6	0.6	0.27	0.1
83 Mercury	50	3(d)	0.25	0.010	0.016	0.016	0.15	0.024	0.53	0.42	0.14	<0.005	1.1	0.35
			Biological Quality Evaluation(g)											
Attached Algae			F		F		F		P					
Bottom-Dwelling Invertebrates			P		G		P		P					
Fish			F		G		P		P					
Overall			F		G		P		P					

(a) MEG = Multimedia Environmental Goals from Cleland and Kingsbury (1977a and b); all values were multiplied by 100 based on personal communication with Kingsbury (August, 1978); all values in μg/g dry weight.
(b) MATE = Minimum Acute Toxicity Effluent; EPC = Estimated Permissible Concentrations.
(c) Based on three sampling campaigns conducted by Battelle in the study area.
(d) Based on potential teratogenic effects (Cleland and Kingsbury, 1977a and b).
(e) Sampled in ash disposal area.
(f) Raw coals sampled at Homer City include those from Helen Mining Company and Helvetia Coal Company (from Upper Freeport Seam) and trucked-in coal (from Lower Kittanning Seam).
(g) The aquatic biota evaluations are based on standing crop, species diversity, and presence of indicator species or families; G = good; F = fair; and P = poor aquatic biota quality.
(h) No data available.

Note: For ease of making comparisons, EPC and MATE values which are used for making comparisons and the field data which exceed them are underlined.

Aquatic Biota Survey

Fourteen aquatic biota sampling sites were selected in seven streams in the study area, as well as in an additional control stream, Ramsey Run, which is about 6 miles (9.6 km) north-northeast of the study area and about 1 mile (1.6 km) east of Indiana, Pennsylvania (Figure 25). Sites were chosen which would provide the best data for evaluating the impact of the existing facilities in the complex on the aquatic biota of the receiving streams. Sampling was conducted both upstream and downstream from potential sources of pollution. Thus, the prior effect of upstream sources of pollution on aquatic biota was included in the assessment of the study area. Only a minimal sampling effort was carried out in Two Lick Creek because a survey by Environmental Sciences, Inc., (1972) reported that this stream had poor water and aquatic biota quality primarily due to acid mine drainage from abandoned strip mines located upstream.

Three groups of aquatic organisms were selected for study: (1) periphyton (attached algae, especially diatoms), (2) benthic macroinvertebrates (bottom-dwelling invertebrates visible to the naked eye), and (3) fish. These three groups of organisms were chosen because of their relative ease of collection, usefulness as water quality indicators, and importance in aquatic food webs.

Attached algae were sampled in triplicate by scraping cobble-size rocks from the stream bottom. The preserved diatoms were prepared for viewing on a microscope slide and then identified according to species. Standing crop was expressed for each species in terms of number of organisms per square centimeter. Finally, total periphyton standing crop and total number of species were calculated for each sampling site.

Bottom-dwelling macroinvertebrates were collected from riffle areas using a Surbur ® sampler. Five replicate samples were taken at all stations and were preserved with Formalin ® and returned to Battelle for sorting, identification, and enumeration. All organisms were identified to the lowest practical taxon, and the resulting data were used to

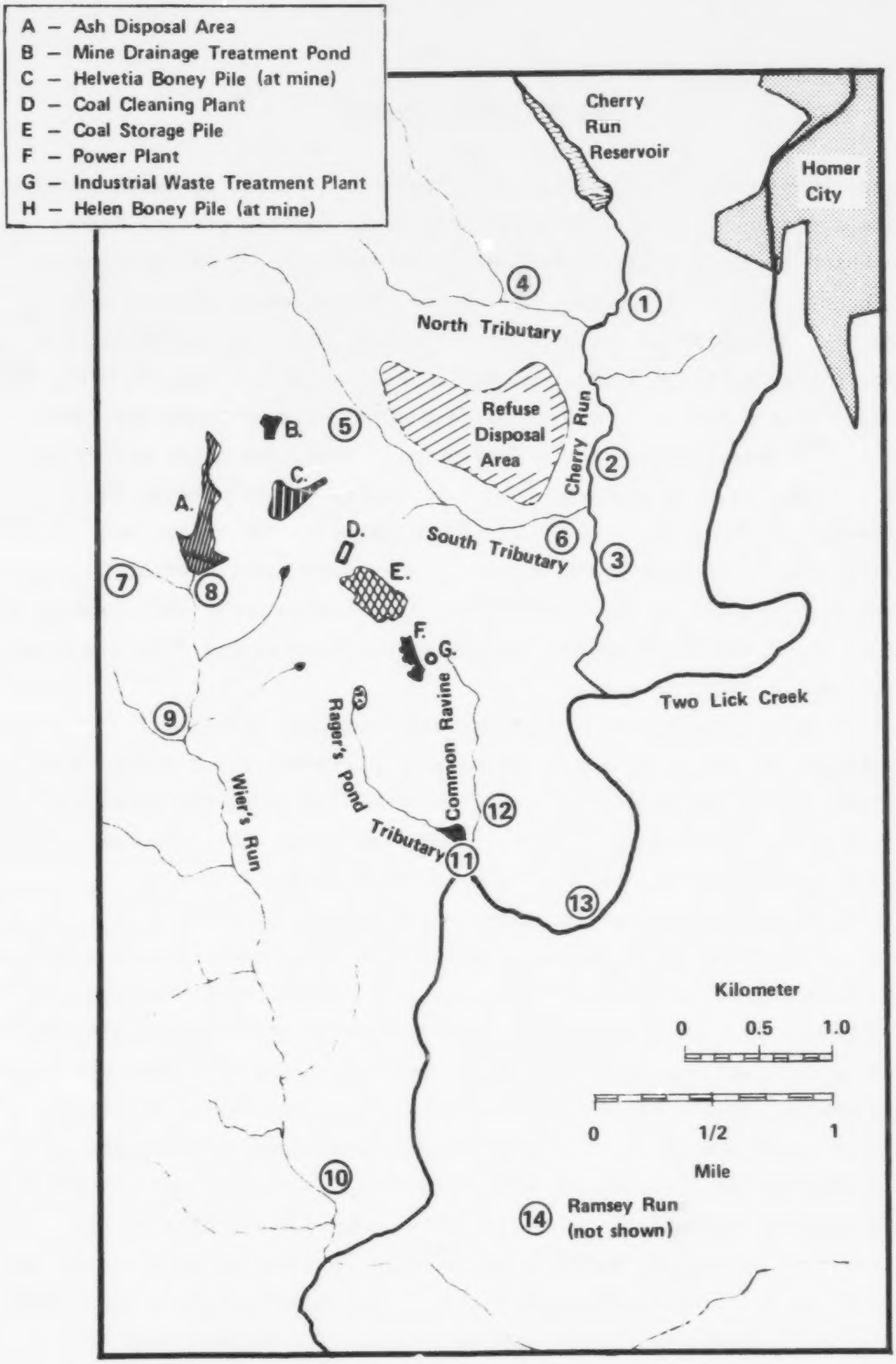
A – Ash Disposal Area
B – Mine Drainage Treatment Pond
C – Helvetia Boney Pile (at mine)
D – Coal Cleaning Plant
E – Coal Storage Pile
F – Power Plant
G – Industrial Waste Treatment Plant
H – Helen Boney Pile (at mine)
Cherry Run Reservoir
Homer City
North Tributary
Refuse Disposal Area
Cherry Run
South Tributary
Two Lick Creek
Rager's Pond Tributary
Common Ravine
Wier's Run
A.
B.
C.
D.
E.
F.
G.
1
2
3
4
5
6
7
8
9
10
11
12
13
Kilometer
0
0.5
1.0
0
1/2
1
Mile
14 Ramsey Run (not shown)

FIGURE 25. AQUATIC BIOTA SAMPLING LOCATIONS(a)

(a) Table 70 describes the locations.

calculate species diversities according to the Shannon-Weaver formula (Shannon and Weaver, 1963).

Fish were collected by using a 4 x 6-ft, 1/4-in.-mesh seine and/or a backpack shocker. Both devices were used during the spring survey, but only the seine was used during the winter survey. Fishing was conducted with approximately equal effort (1/2 hour) at each station. Fish were identified, recorded, and released. Specimens not positively identified in the field were placed in sample bottles, preserved, and returned to the laboratory for identification.

Biological quality was determined for each of eight portions of streams or tributaries surveyed in the study area. Quality of the biota in the control stream (Ramsey Run) was evaluated as good and provided a basis for comparing the other streams. The subjective evaluation of aquatic biota quality in each stream was determined by initially evaluating each of the three groups of organisms surveyed. The evaluations were based on the presence of indicator species, standing crop of diatoms, species diversity of bottom-dwelling macroinvertebrates, and number of individuals per fish species. Finally, overall biological quality ratings of good, fair, or poor were based on the individual ratings for the three aquatic groups.

Stream Surveys

Cherry Run and Tributaries. Cherry Run is a medium-size stream which flows through areas of differing land use. It receives runoff from agricultural, residential, and pasture lands as well as discharges from coal mining and storage operations.

Collections of attached algal (diatom) communities made during December, 1976, and April, 1977, reflect ecological stress conditions in Cherry Run. Dominant species include *Melosira distans*, *Navicula radiosa*, *N. cryptocephala*, *N. viridula*, and *Nitzschia dissipata*, which have been classified as indicative of mild to heavy organic pollution and high inorganic and nutrient content (Patrick and Reiner, 1966, and Lowe, 1974). Organic enrichment was particularly evident at Sampling

Sites 2 and 3; (upstream and downstream of the tributary south of the disposal area; see Figure 25) after the stream flowed through pastureland. Ecological imbalance was expressed by the relatively large numbers of only a few species. Species diversity indices for Cherry Run and other streams are presented in Appendix D.

Benthic macroinvertebrates collected from three sites in Cherry Run indicated the presence of a moderately diverse community. Dominant groups of aquatic organisms included dipteran (fly) and trichopteran (caddis fly), larvae and fingernail clams. Other organisms present included mayfly and stonefly naiads and beetle larvae. Species diversity indices calculated from the total of three Surber samples are presented in Appendix D. Indices greater than 2.0 have been classified as representative of clean stream conditions (Wilhm, 1970). An exception of 0.90 was recorded for Sampling Site 2 in the winter. The standing crop supported at these sampling sites was lower than might be expected.

Fish collections made in Cherry Run contained a total of 18 species. A variety of species were collected including forage fish (minnows, shiners, and dace) and sport fish. Only two species of darter, the barred fantail and the Johnny darter, were collected in this area. These bottom-dwelling riffle species tend to be one of the more sensitive groups of aquatic organisms. The absence of more darter species may indicate periodic poor water quality. In addition, relatively small numbers of fishes were observed or collected from the riffle areas with a seine. This low-standing crop of fishes may also reflect environmental stress in Cherry Run.

North Tributary. The north tributary is a small headwater stream which flows along the northern edge of the proposed refuse area. Dominant numbers of Surirella ovata and Navicula radiosa indicate a source of pollution, possibly inorganic (Lowe, 1974). Spring collections showed a relatively small number of species. Additionally, the presence of large numbers of individuals of two or three species indicated a possible environmental perturbance. This stream was almost totally shaded, which could account for the underdevelopment of the diatom community. The north tributary does not drain any of the existing plant complex and receives little or no industrial or domestic waste. The benthic macroinvertebrate community here was abundant and diverse. Species diversity indices calculated from these collections were the highest in the area, 3.50 in winter, and 3.98 in spring. Although these were calculated from three combined samples, values in this range are characteristic of clean, unpolluted streams (Wilhm, 1970).

Fish collections made in this stream revealed the presence of 12 species. Abundance of fishes in this stream was also high. This stream has a well-balanced and diverse aquatic community, indicating good water and habitat quality.

South Tributary. The south tributary, a small headwater tributary, drains the southern edge of the proposed refuse area. Site 5 was located upstream from existing plant discharges (from coal pile runoff) and from potential runoff (from the new refuse area). The tributary flows through a wooded area and, in the region of the sampling station, was approximately 50 percent shaded. Low numbers of species were found during both sampling periods. Dominant species were indicative of pollution, high nutrients, and inorganic content--*Gomphonema parvulum*, *Navicula crytocephala*, *Navicula radiosa*, *Navicula viridula*, and *Surirella ovata*. Upstream land use for pasture and agriculture were likely sources for nutrient additions.

Runoff from the coal pile was likely responsible for the decreases in standing crop and numbers of species found during the spring survey between the upstream portion of this tributary (Site 5) and that segment near the confluence with Cherry Run (Site 6). The diatom community at the downstream station was extremely depauperate during the spring survey, less so during the winter.

The headwaters of this stream were found to support an abundant and diverse macroinvertebrate community dominated by caddis fly larvae. Also present were two headwater stream species of fish, the creek chub, and blacknose dace. This portion of stream appeared free of external environmental stress. The site further downstream, however, clearly demonstrated a perturbance. Stress was caused by the poor water quality below the coal-pile runoff discharge to this stream. Benthic macroinvertebrates were almost totally absent from the lower reaches as far downstream as its confluence with Cherry Run. Another indication of the poor water quality of this stream was the absence of fishes. Only three species and seven individuals were collected from the downstream sampling site.

Coal-pile runoff and current construction activity have severely stressed both the water quality and biological communities of this tributary. Apparently, dilution with Cherry Run water reduces the negative impacts below detection at the level of effort of this study. No indication of poor stream quality downstream in Cherry Run could be attributed to the addition of waters from this tributary.

Wier's Run and Tributary. The uppermost portion of Wier's Run originates below the existing ash disposal area. No algal growth was apparent on any substrate in this portion of Wier's Run. Analysis of samples showed extremely poor diatom community development, both in numbers of species and standing crop, during both winter and spring sampling surveys.

The tributary to Wier's Run was physically very similar to the portion of Wier's Run below the ash disposal area. Both are small headwater streams flowing through the same wooded area. Standing crops were relatively high during both spring and winter sampling surveys. Spring collections had a relatively high number of species. Dominance was evenly distributed among several species. However, a few of those species were indicative of organic pollution and nutrient enrichment. These conditions were likely due to, or enchanced by, the decomposition of garbage and trash found at several spots along the banks of the tributary.

Benthic macroinvertebrate samples were also collected from both Wier's Run just downstream from the ash disposal area and from the tributary in the same area. A relatively large and diverse community of invertebrates was found to inhabit the triburary stream. Species diversity indices calculated from this tributary were 2.61 and 2.13 for winter and spring, respectively. However, in Wier's Run (Site 8), no invertebrates were found in collections during either sampling trip. Only one fish species was collected from both these areas, the creek chub. On the basis of the periphyton and invertebrate collections, the segment of Wier's Run immediately downstream from the ash disposal area was greatly stressed by poor water quality leaching from the ash pile.

Two additional stations further downstream in Wier's Run were also sampled to determine the downstream extent of the ecological perturbance observed below the ash disposal area. At Site 9, the stream bed widens and deepens, creating long pool areas. Suitable habitats for attached algal development were scarce. The diatom populations found on available substrates were fairly sparse--low numbers of species (possibly seasonal variation, in the winter), and low-standing crop.

Stream characteristics at the farthest downstream site sampled (Site 10) were similar to those found at Site 9. Winter samples showed a larger number of species at this site than at either of the two upstream sites. Standing crops were also greater at this site during both surveys. The dominant organism during both surveys was Diatoma vulgare, classified as indicative of high nutrient conditions (Patrick and Reimer, 1966, and Lowe, 1974). This enrichment was likely due to domestic sewage discharges to Wier's Run upstream of this sampling location.

Benthic invertebrate collections from the downstream sites were also very poor. Few, if any, organisms were collected from the riffle areas of the two sites. The notable exceptions were the large number of Hydropsyche and Cheumatopsyche collected near the confluence with Two Lick Creek. This almost complete dominance by two quite tolerant organisms also indicates that Wier's Run was adversely impacted for its entire length.

Fish collections obtained using both seines and electrofishing equipment further demonstrate the poor ecological quality of Wier's Run.

Only 5 species and 59 individuals were collected from both downstream sites. Extensive attempts to collect fish from these areas produced few additional specimens. Low-standing crop of only a few fish species clearly demonstrates the poor quality of Wier's Run.

Although some recovery was indicated downstream, Wier's Run was generally adversely impacted from the ash disposal area to its confluence with Two Lick Creek.

Common Ravine. The small tributary stream in Common Ravine receives discharges from the sewage treatment plant, the industrial waste treatment facility, and the cooling towers. Substrates were covered with a white-gray cementing material which rendered habitats totally unsuitable for colonization of attached algae or benthic macroinvertebrates.

Diatom populations during both surveys were extremely depauperate. Existing organisms were only of cosmopolitan or tolerant species (Lowe, 1974, and Palmer, 1969). Most species were represented by only one or two specimens.

No fishes or benthic macroinvertebrates were found at this site during either survey. The biological communities investigated in this stream were generally nonexistent due to poor water and habitat quality.

Rager's Pond Tributary. The small tributary stream to Rager's Pond receives runoff from both mining and power plant operation areas. Oxidation of ferrous material in these wastewaters covers the substrates with a bright orange precipitate.

Diatom collections during spring and winter surveys showed extremely depauperate algal communities in this tributary. No growth was apparent except on isolated portions of rocks near the banks which protruded from the water. Two species were found during the winter survey and four during the spring survey. These species were represented by only one to three individuals per sample.

No benthic macroinvertebrates or fishes were found during either survey at this site. Discharges from mining and power plant operations have severely stressed this small stream. Poor water and habitat quality have rendered this stream inhospitable to colonization by aquatic organisms.

Two Lick Creek. The portion of Two Lick Creek which was sampled flows though industrial, residential, and commercial areas. Previous studies (Environmental Sciences, Inc., 1972) have shown this large stream to be an extremely perturbed aquatic system.

Surveys were conducted on only the attached algae community during both winter and spring. The number of species found remained fairly constant between surveys--relatively high in comparison with those in the streams sampled in the area of the coal cleaning facility but very low for a stream of this size. Standing crops were extremely low during both surveys. Dominant species were typical of mild to heavy organic pollution and high nutrient content (Lowe, 1974, and Palmer, 1969).

Ramsey Run. Ramsey Run, a moderate-size stream, flows though a wooded, lightly populated residential area. The stream is bounded by steep banks which are used locally for dumping trash. A 350- to 400 yard area adjacent to the stream had been cleared and graded prior to the time of the spring sampling.

Ramsey Run was sampled in order to obtain additional data on another stream not impacted by the Homer City power complex or other industrial source. Similar collections of periphyton, macroinvertebrates, and fishes were made in this stream. In general, these collections contained fewer numbers than might be expected. However, a diverse and stable community of aquatic organisms did inhabit this stream.

Algae collections during both the winter and spring survey showed evidence of environmental perturbance. The numbers of species found were generally low. Standing crops were high but dominated by large populations of one or two species. Dominant species, Navicula lanceolata, N. crytocephala, and N. Viridula, are characteristic of waters of high mineral content (Patrick and Reiner, 1966) and mild-to-heavy organic pollution (Lowe, 1974, and Palmer, 1969).

Benthic macroinvertebrate collections from this stream revealed a low standing crop, composed of a fairly large number of species. Species diversity indices were 3.20 and 2.58 for winter and spring, respectively, typifying clean stream conditions (Wilhm, 1970).

Only seven species of fish were found to inhabit this stream. The dominant species, the mottled sculpin (Cottus bairdi), is found in high-gradient clean, unpolluted streams (Trautman, 1957). The presence of large numbers of this clean water species indicates good water quality.

Fish Tissue Analysis

Results of the fish tissue analyses for four metals--arsenic, copper, nickel, and zinc--are presented in Appendix D (Table 86). The majority of the fishes collected for analysis were bottom feeders, or those whose food supply is closely associated with the sediments. The ranges of selected metals occurring in the sediments at the approximate locations of the fish collections are presented in Appendix C.

Generally, there were few differences between sites in the levels of the four selected metals in the tissues of the fish species analyzed. In some cases, levels found in the tissues of fish collected upstream of the disposal area tributary were higher than those in tissue of fish taken downstream at Site 3--specifically, levels of all four metals in hogsucker and white sucker tissue.

Levels in samples of muscle tissue ranged between 0.023 μg/g and 0.11 μg/g (wet weight) for arsenic and 13.9 to 33.4 μg/g for zinc. Higher values were reported for analysis of whole minnows which included gut contents and therefore may reflect levels found in the sediments.

Levels of arsenic reported in the literature are generally within the range found in the Homer City samples. Tong, et al., (1974) reported 0.037 to 0.090 ppm arsenic (wet weight) for lake trout from Lake Cayuga; Uthe and Bligh (1971) reported 0.05 to 0.15 ppm arsenic (wet weight) for fishes from polluted and unpolluted area in the Great Lakes region. The levels found in the tissues of fishes from the Homer City area fall below the 0.5 ppm concentration recommended for arsenic in muscle tissue for human consumption (Rooney, 1973).

Levels of zinc found in fish tissue at Homer City were similarly within ranges reported in the literature--11 to 20 ppm (wet weight) for fishes from polluted and unpolluted area of the Great Lakes region (Uthe and Bligh, 1971). Those values that were considerably higher than 20 ppm were again from samples of whole minnows.

Levels of nickel and copper found in fish tissue reported in the literature for fishes from clean and polluted waters are within the range of 0.2 to 1.3 ppm (wet weight) (Tong, et al., 1974; Uthe and Bligh, 1971; and Lucas, et al., 1970). These same authors report the range of levels of copper in fish tissue as 0.015 to 1.28 ppm (wet weight). Levels found in fish muscle tissue at Homer City ranged from 5.73 to 98.8 ppm (wet weight) for copper and 1.01 to 24.9 ppm (wet weight) for nickel. These values are considerably higher than would be expected. It should be noted here that two types of sample preparation were utilized in making the metals determinations. One method consisted of homogenizing whole fish (minnow) samples by hand using a glass and Teflon homogenizer. Larger tissue samples were homogenized in a blender with blades primarily of iron, nickel, and chromium. Tissue samples prepared by hand showed lower copper and nickel values than those prepared by the blender method. Hence, little significance can be applied to these copper and nickel values.

Stream Biological Quality

The aquatic survey of the area of the Homer City power complex covered eight streams. Quality in a control stream (Ramsey Run) was evaluated as good and provided a base for comparison. Stream quality ranged from excellent to very poor. A subjective evaluation of the streams surveyed in this study is presented in Table 13. A subjective quality evaluation was made of each biological group investigated; an overall stream quality rating was then made for each stream.

Three streams, the tributary to Cherry Run north of the refuse area, the tributary to Wier's Run, and Ramsey Run, were considered to have good overall biological quality. Additionally, the upstream portion of

TABLE 13. BIOLOGICAL QUALITY EVALUATION OF STREAMS SURVEYED IN THE AREA OF THE HOMER CITY POWER COMPLEX

Biological components	Cherry Run	Tributary to Cherry Run north of refuse area	Tributary to Cherry Run south of refuse area		Tributary to Wier's Run	Wier's Run	Rager's Pond tributary	Common Ravine	Ramsey's Run
			Upstream	Downstream					
Periphyton	F	F	F	P	G	F	P	P	F
Benthic macro-invertebrates	P	G	G	P	G	P	P	P	F
Fishes	F	G	G	P	G	P	P	P	G
Overall rating	F	G	G	P	G	P	P	P	G

G = Good
F = Fair
P = Poor

the tributary south of the proposed refuse disposal area was considered to be of good quality.

Cherry Run was evaluated as having fair biological quality based on the number of fish species inhabiting this stream. However, the quality of the biological community inhabiting Cherry Run has been affected by both plant and mining operations in the area. Low standing crops of macroinvertebrates and fishes clearly demonstrate this perturbance.

The remaining streams--Wier's Run, Rager's Pond tributary, Common Ravine tributary, and the downstream portion of the tributary south of the disposal area--were all considered to have extremely poor biological quality.

COAL CLEANING REFUSE DISPOSAL SITE

Site Description

Refuse from the Homer City coal cleaning plant will be disposed of on a hillside site 3600 feet northeast of the plant (Figure 26). There are approximately 200 feet of relief (elevation 1100 to 1300 feet) in the disposal area, and natural slopes average about 12 percent. Size of the disposal site is approximately 180 acres.

East of the site is Cherry Run, which flows south to Two Lick Creek. North and south of the site are unnamed tributaries to Cherry Run. Total drainage area of the two tributaries is about 2000 acres. On the basis of USGS flow records for Two Lick Creek, average annual discharge from this basin is equivalent to 21.68 inches. Therefore, combined average discharge from the unnamed tributaries can be estimated at about 5.0 cfs or 2250 gpm.

The site is underlain by sandstone, siltstone, and shale. Bedding is nearly horizontal. Two principal waterbearing formations beneath the site are the source of numerous small springs on the hillsides on the southeast and west sides of the site. The discharge from each of these springs is generally less than 5 gpm. The location of the springs and the regional geology suggest groundwater flows from north-northwest to south-southeast.

Soils in the refuse area were examined by the disposal facility design engineer. The fairly shallow (1 to 10 feet) soil layers over bedrock were found to be silt loams. The U.S. Soil Conservation Service has rated the erosion potential of these soils as moderate. No permeability tests were performed on the natural soils of the area, but the disposal facility design engineer estimated permeability at less than 10^{-6} cm/sec.

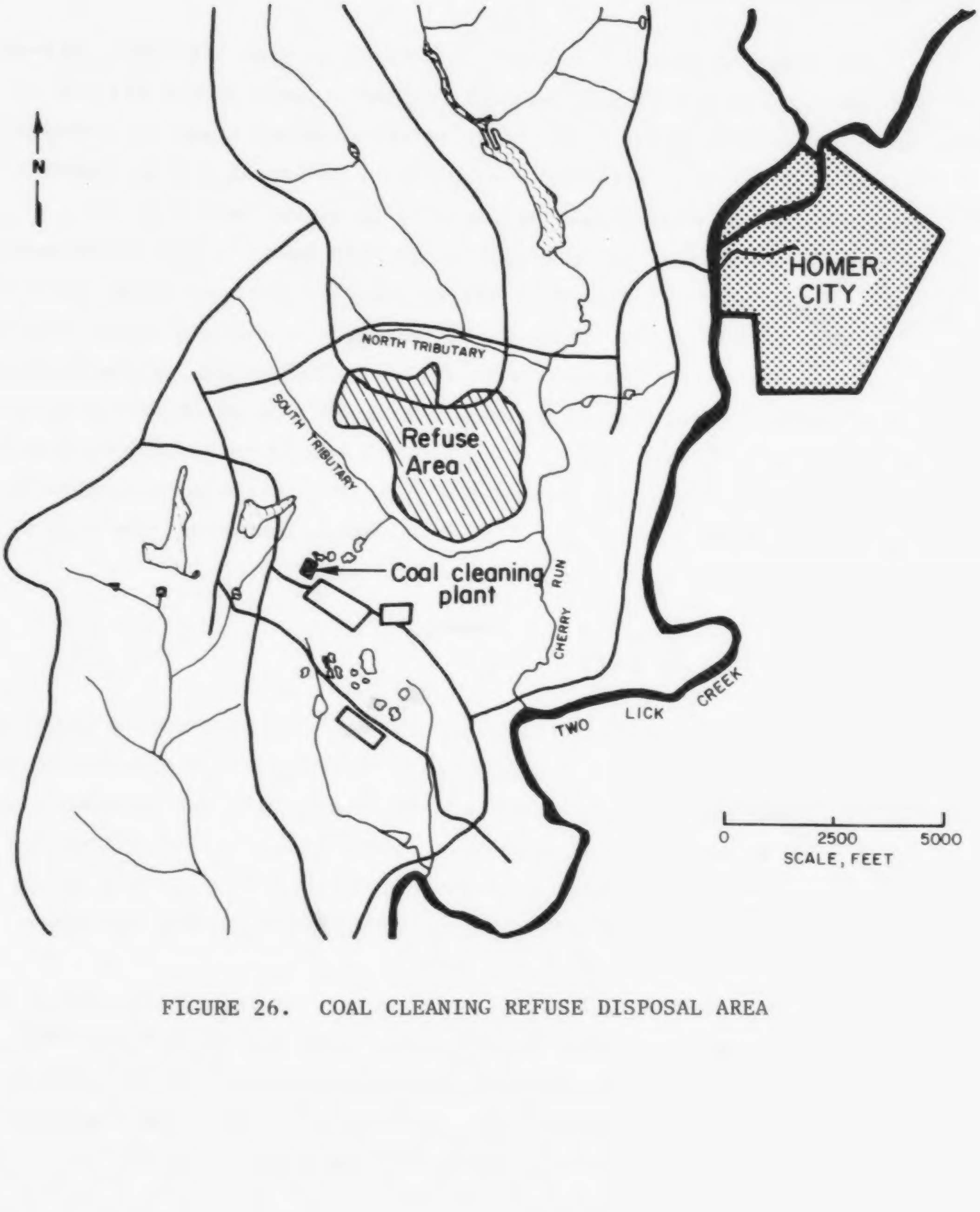
N
HOMER CITY
NORTH TRIBUTARY
SOUTH TRIBUTARY
Refuse Area
Coal cleaning plant
CHERRY RUN
TWO LICK CREEK
0
2500
5000
SCALE, FEET

FIGURE 26. COAL CLEANING REFUSE DISPOSAL AREA

Facility Design

Landfilling Stages

The disposal facility was designed for a 30-year lifetime. Refuse disposal, by landfill, will be done in four stages (Figure 27) and involve four fill areas. The first refuse disposal stage is intended to extend over a 1-year period and will fill a valley on the southwest flank of the disposal site. Refuse will be placed behind a nonimpounding embankment to an elevation of 1170 feet. Stage II disposal will be atop Stage I; this will extend the fill area and raise the elevation to 1290 feet. Stage II is intended to last for about 9 years.

Stage III refuse disposal will fill a valley on the southeast flank of the hill, behind a nonimpounding embankment, to an elevation of 1175 feet. Stage III will last for 4 years. Stage IV refuse disposal will be atop Stage III; this will extend the fill area to 180 acres and raise the elevation to a maximum of 1290 feet. When completed, the site will hold 30 million tons of coal cleaning refuse.

Water Protection Measures

The facility design incorporates several water-protection measures. Diversion ditches will be constructed to reduce surface erosion on the site. These will divert all surface drainage around the disposal area into a siltation basin. In addition, runoff from the disposal surface itself, which might be high in suspended solids, will be directed to the siltation basin. There will be separate siltation basins for Stages I and III.

Siltation basins were designed to conform to recommendations of the Pennsylvania Department of Environmental Resources (Penn DER). The Stage I and Stage III ponds have storage capacities of 0.68 and 0.78 million cubic feet, respectively. A 12-inch pipe has been installed for normal discharge of clarified water from the pond. However, emergency

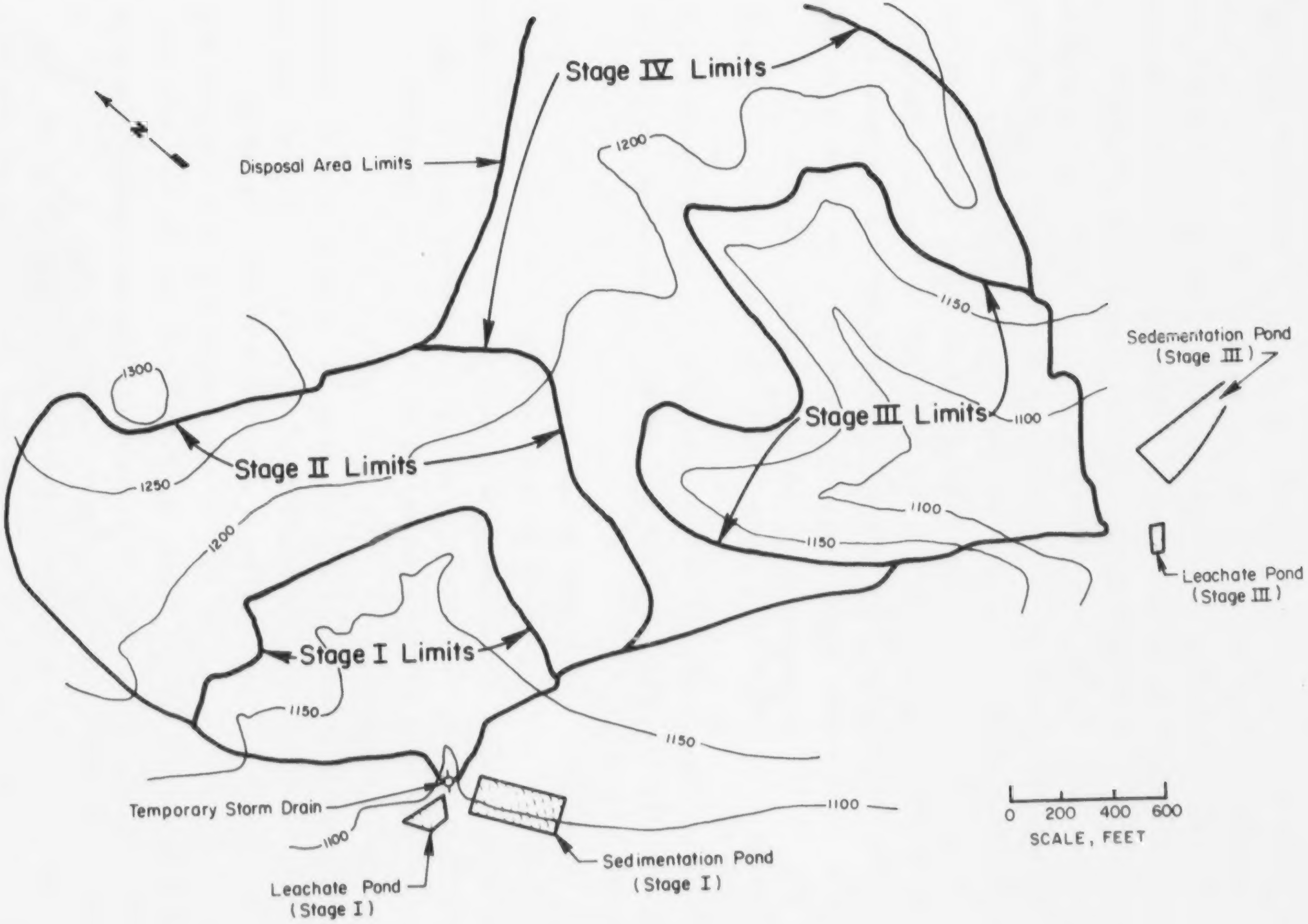
N
Disposal Area Limits
Stage IV Limits
Stage III Limits
Stage II Limits
Stage I Limits
1300
1250
1200
1150
1100
Sedementation Pond
(Stage III)
Leachate Pond
(Stage III)
Temporary Storm Drain
Leachate Pond
(Stage I)
Sedimentation Pond
(Stage I)
0 200 400 600
SCALE, FEET

FIGURE 27. DISPOSAL STAGES AND POND LOCATIONS

overflow weirs have been installed to prevent overtopping the dikes in the event of excessive storm runoff. No treatment other than settling is provided for sedimentation-pond discharges.

During construction and during the earliest period of refuse disposal in Stage I, natural surface drainage will be diverted through the nonimpounding embankment via a 12-inch pipe (Figure 27). This diversion was designed to be used until the fill reaches a predetermined elevation (1110 feet), at which time the surface diversion ditches and sedimentation pond will be used and the pipe will be grouted.

According to the facility design engineer, all hydraulic characteristics of the ponds and ditches have been designed to conform to Penn DER guidelines and the Mining Enforcement and Safety Administration's (MESA) design criteria for coal-cleaning refuse disposal facilities. The design storm for the surface drainage facilities was a 100-year storm, which corresponds to a 2.7-inch rainfall over a 1-hour period.

Surface waters will be further protected by clearing only the land area required for each stage as it is needed and by prompt revegetation of completed areas.

The disposal facility design calls for groundwater in and around the disposal area to be protected by means of a leachate collection and treatment system. A rock underdrain, consisting of 3- to 6-inch cobbles wrapped in filter cloth, has been placed in the major valley bottoms. Smaller drains of similar construction are to be installed wherever springs are encountered.

The design called for these drains to be constructed on the existing natural ground surface. The facility design engineer reasoned that the existing soil surface, consisting principally of silts, would be relatively impermeable and that leachate would flow preferentially into the underdrains, thereby preventing infiltration of leachate into the ground and eventually into the groundwater. The main underdrains were designed to handle an estimated peak flow of 150 gpm.

The underdrains will carry leachates to two leachate ponds. The ponds serve as equalization basins to capture peak flows and provide a relatively uniform feed rate to the leachate treatment system. The ponds are designed for 24-hour retention of the estimated 150 gpm peak flow from the underdrains. Collected leachate will be pumped to a treatment facility. An 8-inch pipe has been installed near the crest of the pond dike to serve as an "emergency overflow".

Water quality characteristics of the leachate are estimated by the design engineer to be as follows:

pH	2.0-2.5
Acidity	5000-7000mg/1
Iron	5000-1000 mg/1
Suspended Solids	250 mg/1

No estimate or mention of other possible water quality parameters was made by the design engineer.

The leachate will be treated at an off-site mine-drainage-treatment facility of the Helvetia Coal Company. The only treatment known or expected to be provided by this facility is lime neutralization and settling. This treatment has been approved by the Penn DER, which views coal preparation refuse the same as coal ash and other mine wastes and considers acid drainage to be the only important potential pollutant.

Potential Operational Problems--
Pollution Potential

Certainly leachate will be generated in this disposal facility, as the facility design engineer has anticipated. However, evidence from numerous investigations of various types of coal, coal ash, and coal refuse leachates indicates that other water quality parameters than those anticipated by the facility design engineer may be affected. Among these are sulfate, calcium, various metals, and total dissolved solids.

The underdrain system is only one possible avenue of escape for leachate. The facility design engineer assumed that the underdrain would be placed on top of the natural soil, which as mentioned before consists primarily of silts. The engineer expected that the silty soil would prevent downward migration of the leachate and that the leachate would flow preferentially into the underdrain system. This is not necessarily so, however. If the underdrain should become plugged, or hydraulically overloaded, or if differential settlement should reverse the grade of the drain locally, a head may develop within the refuse which would allow leachate to penetrate the silt soils and percolate downward toward the groundwater table. More importantly, however, the natural soils were disturbed and in places removed during site preparation, probably to improve the grades. In fact, the main underdrain for Stage I has been constructed partly in bedrock, which in that area is sandstone. A certain amount of leachate may find its way out of the site and into groundwater or surface water via that path.

Another potential point of leachate migration is the temporary storm drain, described previously, to divert natural drainage through the embankment during construction and early disposal. This pipe has been installed at a lower elevation than the leachate collection drain at this point. Therefore, any leachate formed in Stage I will flow toward the temporary storm drain rather than the leachate collection drain. Water is already channeling alongside this pipe, through the embankment. Leachate will follow this same path, unless the pipe and the embankment below the level of the leachate drain are carefully sealed.

Recommendations for Future Monitoring

To measure the infiltration of leachate into the soil within the disposal area, soil testing should be done before and during operation. This will enable the owners of the cleaning facility to measure the rate of migration of leachate down through the soil toward the groundwater. Measurement before the facility is in operation is essential to establish background levels. Tests should be run on the water quality parameters described previously in this section, especially for metals, which have a tendency to be adsorbed on the soil particles.

At least three deep soil borings should be made for the purpose of establishing clearly the local groundwater gradient. These borings could also be used for groundwater monitoring.

Monitoring of the possible discharges described above should be initiated. These discharges include (1) treatment system effluent, (2) sedimentation and overflow, and (3) the temporary storm drain discharge. The leachate pond should also be monitored to establish the characteristics of this particular leachate. Stream monitoring in the tributaries to Cherry Run north and south of the site, downstream of the disposal area, will help detect any leachate that might get into the sandstone bedrock and be carried laterally to a surface discharge point. Stream monitoring will also help detect any other possible seepage.

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Note: Appendix references appear at the end of each appendix.

APPENDIX A

FUGITIVE DUST MONITORING

Location of Monitoring Sites

In designing an air monitoring system, the first consideration is generally given to the purpose for monitoring. Are maximum concentrations of primary interest or is a spatial representation of average concentrations of special importance? In monitoring fugitive dust near the Homer City coal cleaning facility, Battelle wanted to obtain both a spatial distribution of the dust deposition and the magnitude of the maximum concentrations. The second important consideration is the nature of the emissions. Since the dusts in the study area are fugitive in nature, it is reasonable to assume that the greatest impacts will occur within short distances downwind from the sources; therefore, monitoring efforts should be concentrated in that area.

Ten monitoring sites were selected, carefully keeping in mind the considerations noted above. A Fugitive Dust Emission Model was developed by Battelle to aid in the monitoring site selection (see section on Modeling Activities in this Appendix). The locations of the monitoring sites are shown in Figure 2. Five sites (1, 2, 3, 4, and 7) are located in the immediate vicinity of the power plant operations. The remaining sites (5, 6, 8, 9, and 10) are well removed from the center of these operations.

Sites 1, 3, 4, 8, and 9 were selected to show a spatial distribution of dust concentration (including the maximum) during periods of prevailing wind flow from the south-southwest. Site 3 would also provide baseline data prior to the start-up of the coal cleaning plant. Site 2 would show the maximum concentrations from the coal pile when the wind was from southwest-west. Site 5 was selected to evaluate the air quality impact of the ash disposal area when the wind is from the west or southwest. Site 6 served as a site for background concentrations for any wind direction between southeast to north.

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Site 7 was selected to show the air quality impact from plant operations for a northwest wind. Finally, Sites 9 and 10, 1800 and 2000 meters, respectively, from the plant were chosen to indicate whether fugitive dust was being transported to these distances.

Diffusion Model Results

The results obtained from the Fugitive Dust Emission Model developed by Battelle to evaluate potential sites for monitoring are summarized below. The distances given agree favorably with the locations of the monitoring sites situated around the power complex's operations. The term "major axis" relates to the nonuniform shape and specifies the orientation of each source. (See the following section on Modeling Activities in this appendix.)

Source	Wind Direction	Distance of Maximum Fallout Concentrations, meters
Coal Pile	Perpendicular to Major Axis	250-400
	Parallel to Major Axis	400-500
Boney Pile	Perpendicular to Major Axis	150-300
	Parallel to Major Axis	200-400
Ash Disposal Area	Perpendicular to Major Axis	0-100
	Parallel to Major Axis	0-100

The locations of the ten sampling sites in relation to the dust sources are listed below:

Site 1 - Located about 175 meters northeast of coal storage pile and 300 meters northeast of the coal cleaning facility

Site 2 - Located about 200 meters southeast of the coal storage pile

Site 3 - Located about 150 meters northwest of the coal storage pile and 50 meters northeast of the coal cleaning facility

Site 4 - Located about 400 meters north of the coal storage pile and about 300 meters east of the boney pile

Site 5 - Located about 200 meters east of the ash disposal area

Site 6 - Located on a farm about 1600 meters southwest of the coal cleaning facility

Site 7 - Located about 500 meters southwest of coal storage pile and adjacent to an unpaved parking lot at the property line of the power complex

Site 8 - Located about 1200 meters north of coal storage pile in an area that is being readied to handle the refuse from the coal cleaning facility

Site 9 - Located about 1800 meters north of the coal storage pile near the property line of the power complex

Site 10 - Located on a farm about 2200 meters northeast of the coal storage pile.

Fugitive Dust Sources

Fugitive dust sources identified on the power complex property include an ash disposal area, where fly ash and bottom ash are routinely deposited by trucks; a boney pile, which serves as a refuse area for undesirable coal from the mining operations; and a large coal pile from which coal is fed into the coal-fired boilers. Future potential sources include the proposed coal cleaning facility to be located adjacent to the coal storage pile, and the proposed refuse area for this facility. These sources are shown in Figure 2.

The ash disposal area encompasses about 17.7 acres and is irregular in configuration. Bottom and fly ash are spread uniformly over the area; the height of the ash disposal area is only slightly above ground level.

The boney pile is also of irregular shape and covers an area of about 11.1 acres. This pile extends well above the ground, and the average height is 60 feet.

The largest source of dust, with regard to both land area and amount of airborne coal particles expected, is the coal storage pile. It occupies an area of approximately 20 acres and is of rectangular configuration. The coal pile towers well above the ground, averaging about 100 feet in height throughout its length and breadth.

The coal cleaning facility is a ten-story structure which will also be a fugitive dust source. As the plant will be enclosed with sheet metal, it is expected that the rate of emissions will be lower than those characteristic of older coal cleaning plants.

Other fugitive sources near the coal cleaning facility operations include vehicular traffic and construction activities. Construction has been ongoing for a number of years and is projected to continue for at least two more years. Also, coal from two storage silos is carried by conveyor belts and deposited onto the coal pile. Coal particles are released during this operation. Although the conveyor belts were not identified as a principal source of fugitive dust since they are almost fully enclosed, coal dust does escape from the bottoms of these belts.

Modeling Activities

Description of Model and Modeling Approach

Battelle's Fugitive Dust Emission Model(A-1) is based on U.S. EPA's Multiple Point Source Model (PTMTP).(A-2) It predicts hourly mass concentrations of fugitive dust at any number of downwind distances. Several major alterations were made to EPA's PTMTP.

First, sources of fugitive dust were treated as area sources because of the dimensions of the area occupied by these types of sources. For example, the dimensions of the coal pile are 1.36 x 0.6 km, or 21.5 acres. To consider each source as an area source, the concept of a virtual point source was programmed into the model.(A-2) This assumes that the area sources are squared and requires the user to input the length of one side. In the study at the power plant, each source was angular in configuration. Therefore, each fugitive dust source was subdivided into area sources approximately square in configuration.

To mathematically permit the deposition of fugitive dust particles, a simple particle deposition function was incorporated in the model. The amount of material deposited on a receptor location is a function of wind speed, emission rate, distance, and particle size, density, and shape. As wind speed increases, more dust becomes entrained in the surface circulation (i.e., the emission rate increases), thereby creating a greater likelihood for a large amount of dust deposition. The smaller the size, the less dense the particles released into the wind and the further downwind they will be transported before settling to the ground. The distance where the maximum amount of fallout will occur is obviously dependent on the wind speed, particle size, density, and shape.

The particle deposition function (Vx/u) was programmed in the model as a distance. V, the settling velocity, was assigned a velocity which reflected a range of particle sizes. The coal pile at Homer City is believed for the most part to be made up of granulated coal particles greater than 30 microns in diameter. Thus, in the modeling work, it was assumed initially that most of the particles released from fugitive sources were greater than 30 microns in radius. Later it was found that predicted concentrations were independent of particle sizes greater than 15 or 30 microns. The deposition function was applied to all receptor distances and the resulting value was assigned to receptor height. This approach effectively increased receptor heights at all downwind distances for a flat terrain. By defining a deposition function in this manner, one does not have to manipulate plume centerline calculations, which coincidentally are normally not relevant where dealing with coal storage and coal refuse sources. The height of the local terrain is then added to the height determined by the deposition function.

A third modification of EPA's PTMTP involved the formulation of an emission rate rather than a direct input of emissions for each fugitive dust source. First approximations of emission rates for each of the sources in the study area were based on an article written by S. L. Vekris, M.Sc., and published in the Ontario Hydro Research Quarterly.(A-3) The study on dispersion of coal particles from a storage pile was conducted at the Lakeview Generating Station on the north shore of Lake Ontario. Mr. Vekris found that for a coal pile covering 40 acres and extending from 0 to 30 meters above the ground, and for a wind speed of about 9 m/sec, an emission rate of 50 g/sec was reasonable to assume in modeling work for particles greater than 30 microns in radius.

Subsequently, a constant was calculated which expressed the ratio of the acreage occupied by each source of fugitive dust at the Appalachian power station to the acreage of the coal pile at the Lakeview Generating Station. The value of this ratio is then multiplied in the emission rate equation by the square of the wind speed. The amount of dust released, whether it originated from a coal, ash, or terrestrial source, has been programmed to be directly proportional to the energy imparted by the wind, that is, to the square of the wind speed.

Finally, a constant, K, was formulated in the emission rate equation which is used after the first computer run in estimating the emission rate for all of the sources. The constant represents the value of the slope of the regression line. The general form of the emission rate equation is

$$Q = K \times u^2 \times \frac{\text{Area (acres)}}{40 \text{ acres}} \quad .$$

Additional modifications to EPA's PTMTP included the elimination of the plume rise routine. It was assumed that none of the sources of fugitive dust considered in this study imparted any thermal buoyancy to the airborne particles.

Methodology for Determining Coefficient of Emission

To determine the value of the coefficient of emission, formulated in the emission model and discussed in a previous section, a linear regression analysis was performed using the observed data and the model's first approximations. A linear regression analysis is a statistical method which correlates one variable to another. It involves the theory of the minimization of the sum of least squares.

If it is assumed that a straight line approximately describes the fit of observed data to the model's predictions of the observed concentration, then this relationship takes the following form and is commonly referred to as the line of regression:

$$Y = a + bx,$$

where a and b represent the intercept and slope, respectively. In determining the values of a and b, it becomes necessary to decide which line best described the observed data and model first approximations. The principle of least squares aids in calculating the values of the intercept, a, and the slope, b. It states that the line of best fit to a series of values is that line about which the sum of the squares of the deviations (the difference between the line and the actual values) is a minimum.

The result of the sum of least squares is given in the following form of the line of regression:

$$P = 59.5 + 1.47 \ x \ .$$

The value of the slope of the line, 1.47, now becomes the value of the coefficient of emission, K. This value was substituted into the emission rate equation, and the results of Battelle's Fugitive Dust Emissions Model are shown in Figure 28. A line that best fits the predicted versus observed data has been drawn.

Results of Diffusion Modeling

The development of a reliable diffusion model which could be applied to fugitive dust sources was achieved. Battelle's Fugitive Dust Emission Model served two functions: one, to aid in selection of monitoring sites, and two, to predict particulate concentrations at the monitoring sites or at any desirable location.

The model's output, which was studied in selecting potential sites for monitoring, is summarized below. The term "major axis" refers to the longest axis of the source configuration.

Basically, the effectiveness of Battelle's Fugitive Dust Emission Model in predicting concentrations can be best illustrated by Figure 28. In constructing Figure 28, an average concentration of all 24-hours for the three campaigns was determined from the observed and predicted data and plotted for each monitoring site. A regression line has been drawn that best fits the data points. Perfect correlation would exist between observed and predicted concentration if all data points would lie along the regression line.

With any diffusion model, perfect correlation between observed and predicted concentration is seldom, if ever, achieved. Figure 28 shows that perfect correlation between what the model predicted and what was observed was not achieved. However, it is quite an accomplishment that the correlation is good or that the scatter of data points about the regression line is minimal. Diffusion modeling of fugitive dust sources is extremely more difficult than modeling of point sources with stacks. More is known about the dispersion of effluent from stacks than the dispersion of fugitive dust (coal dust) from unconfined sources such as the coal pile, and the ash disposal area.

Since Battelle's Fugitive Dust Emission Model is a Gaussian diffusion model, its sensitivity to input data is similar to most point source models. In particular, conclusions which have been determined from the model's response to the input data are summarized below:

(1) It was found that the predicted concentrations were independent of particle size greater than 15 microns; that is, the predicted concentration remained

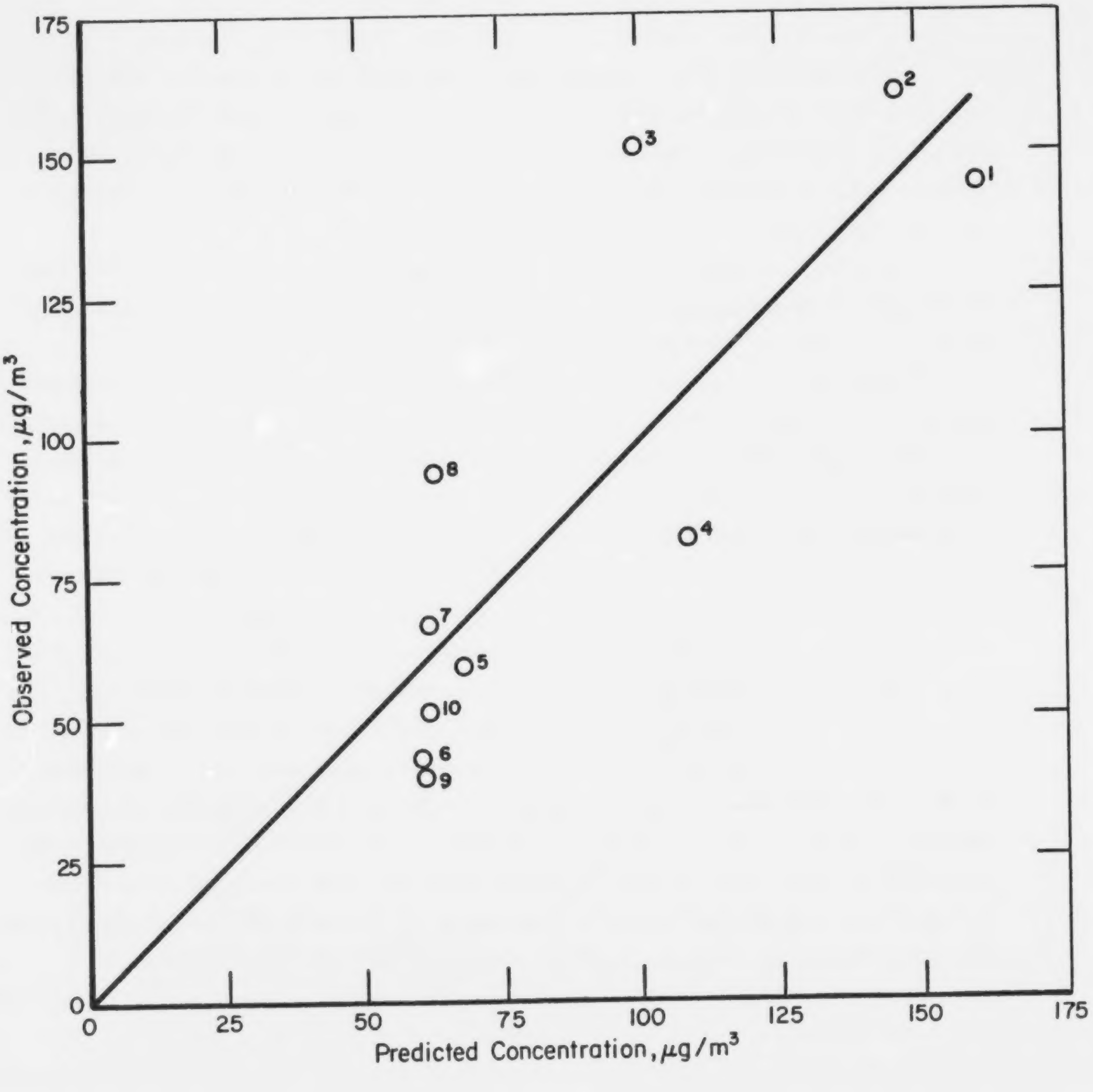

FIGURE 28. RESULTS OF LINEAR REGRESSION ANALYSIS (PREDICTED VERSUS OBSERVED)

essentially unchanged for any particle size 15 microns or greater.

(2) Long-term predictions have less random scatter from observed concentrations than short-term predictions because the random atmospheric dispersion processes, not accounted for by the diffusion model, are averaged out in the passage of time. This is illustrated by a set of concentration data presented in Table 14. It should be noted that the predicted concentrations do not include the background concentration, which has been estimated to be between 30 and 40 $\mu g/m^3$.

(3) During periods of light (1-4 mph) and variable winds, essentially zero concentration was predicted at all sites. This does not include a background concentration of 30-40 $\mu g/m^3$. The observed concentrations were significantly greater than those predicted at sites situated

TABLE 14. SHORT-TERM AND LONG-TERM CONCENTRATIONS VERSUS OBSERVED CONCENTRATIONS

Sites	Predicted(a) Concentrations 2nd 24 hr Campaign III	Observed Concentrations 2nd 24 hr Campaign I	Predicted(a) 24-hr average Concentrations All Campaigns	Observed 24-hr average Concentrations All Campaigns
1	100	325	68	141
2	55	250	58	161
3	3	392	26	152
4	11	144	32	77
5	4	78	6	60
6	0	38	0	44
7	0	68	1.5	68
8	8.3	145	2	95
9	5	42	1	40
10	6	57	1	51

* A background concentration of 30-40 $\mu g/m^3$ should be added to the predicted concentrations.

close to plant operations. For the wind pattern shown in Table 15, the predicted and observed collection are shown in Table 16. With the addition of background concentrations to the predicted concentration, the model at some of the monitoring sites underestimated dust concentrations.

Possible Causes of Scatter About Regression Line

Figure 28 shows a significant scatter about the line of regression. This could be attributed to several factors.

First, a number of sources were not included in the modeling work because of their nature. These include construction activities, vehicular traffic, and parking lots, and the conveyance and dumping of granulated coal from several storage silos onto the coal storage pile. After careful examination of the observed data and the model's predictions, it is believed that all of these sources plus the general dusty surfaces of the power plant are, in some instances, contributing significant amounts of dust. It is believed that stack emissions, under certain meteorological conditions, contributed a significant amount to the total mass particulates collected at several of the monitoring sites.

The results of an optical review of the sampling filters for Campaigns I and II are given in Tables 19, 20, and 21 in the section on Microscopic Analysis on page 128. On numerous occasions there were at least some deposits of soot on the sampling filters. The soot either was released from the stacks, was emitted as a product of combustion associated with the diesel-fired equipment, such as coal trucks, or was reentrained off the grounds of the power plant and onto the filters. For example, during Campaign II at Sites 5, 6, 9, and 10, ash constituted almost half of the total mass concentration. It is highly unlikely to expect the ash disposal area to be the principal source of the ash since all of the filters at Sites 5, 6, 9, and 10 had a moderate-to-large amount of soot deposits. In particular, one filter (at Site 10--operated for 24 hours) was reported to be sooty.

Soot deposits were also reported at the sites located on plant property (Sites 1, 2, 3, 4, 7, and 8). Here soot may be originating off the plant grounds and/or originating from vehicular traffic. Notice too that there

TABLE 15. WIND SPEED AND DIRECTION DURING CAMPAIGN II--FIRST 24-HOUR PERIOD

Date/Hour	Wind Direction	Wind Speed,[a] mph	Site
Jan. 5, 1977			
2000-2100	50	2.0	1
2100-2200	315	3.0	2
2200-2300	165	4.0	3
2300-2400	150	2.0	4
Jan. 6, 1977			
2400-0100	80	1.5	5
0100-0200	135	1.0	6
0200-0300	140	3.0	7
0300-0400	85	2.0	8
0400-0500	60	2.5	9
0500-0600	50	3.5	10
0600-0700	35	2.0	
0700-0800	225	2.5	
0800-0900	230	2.0	
0900-1000	242	2.0	
1000-1100	235	2.5	
1100-1200	230	4.0	
1200-1300	240	4.0	
1300-1400	230	5.0	
1400-1500	237	7.0	
1500-1600	225	10.0	
1600-1700	225	8.5	
1700-1800	225	7.5	
1800-1900	225	8.5	
1900-2000	220	7.5	

(a) Conditions were not calm through the entire 24-hour period. The wind direction became more defined in the second 12-hour period.

TABLE 16. COMPARISON OF PREDICTED VERSUS OBSERVED CONCENTRATIONS DURING PERIODS OF LIGHT VARIABLE WINDS DURING CAMPAIGN II--FIRST 24-HOUR PERIOD

Date/Hour	Site	Predicted Concentration[(a)] µg/m³	Observed Concentration, µg/m³
		January 5, 1977	
2000-2100	1	23	95
2100-2200	2	9	18.3
2200-2300	3	12	136
2300-2400	4	1	67
		January 6, 1977	
2400-0100	5	7	96
0100-0200	6	0	76
0200-0300	7	0	110
0300-0400	8	1	96
0400-0500	9	1	41
0500-0600	10	1	82

(a) The predicted concentrations do not include a background concentration of 30-40 µg/m³.

was no significant amount of tertiary deposits on any of the filters. This indicates that construction dust, in itself, is not a major source of fugitive dust at the power plant and that most of the dust on the plant's grounds originated from coal or ash sources.

Third, the method used in averaging hourly wind direction and wind speed data may account for some scatter about the line of regression. For example, during a given hour, the direction of the wind fluctuated quite severely, and it is difficult to include these fluctuations when representing the wind directions for a given hour with a single value. To remedy this, wind direction data should be averaged over 15-minute intervals in any future studies.

Survey Data

Particulate Concentrations

All of the samples were collected on 8 x 10-inch fiber glass, high-volume filters, for periods of 12 or 24 hours. The filters were weighed before and after each sampling to determine the mass of the particles collected. The weighing of samples was performed by Battelle-Columbus personnel.

Generally, the maximum concentrations were observed at Sites 1, 2, and 3. These sites are located adjacent to the coal storage pile; also, the maximum concentrations occurred during the 8 a.m. to 8 p.m. sampling periods. During the first campaign (Friday, December 17 to Sunday, December 19, 1976), sampling was conducted on the weekend to reduce the impact of fugitive emissions from construction activities. The particulate mass concentrations found at each sampling site for each time frame are given in Table 17. The average (arithmetic) concentration for the 12-hour samples was 114.0 $\mu g/m^3$, while the average for the 24-hour samples was 52 $\mu g/m^3$. The maximum and minimum concentrations for the 12-hour samples were 564.0 and 30.0 $\mu g/m^3$, respectively, while the maximum and minimum concentrations for the 24-hour samples were 110.0 and 28.0 $\mu g/m^3$, respectively.

During Campaign III, a particle sizing distribution sampler was operated at Sites 2 and 3; however, valid data were obtained only at Site 3. Approximately 44 percent of particles were in the 0 to 1.1 micron range. These data are presented in Table 18.

Microscopic Analysis

The objective of the microscopic analysis was to provide a distinction between the various fugitive dusts such as pollen, construction dust, coal dust, and coal ash dust.

Each filter pad was examined under a low-power stereomicroscope to see whether the particulate matter was evenly distributed and whether the pads were smeared during handling. Once these conditions were ascertained, a small piece, approximately 1/2-inch square, was cut from the pad and further analyses were conducted on these small pieces. The small pieces of filter pad were placed on a glass slide and a drop of lens immersion oil (index

TABLE 17. PARTICULATE CONCENTRATIONS IN THE VICINITY OF THE COAL CLEANING FACILITY

Sampling Site	Date	Time	Suspended particulates concentration, $\mu g/m^3$
		12-Hour Samples	
1	17-18 Dec 76	8 p.m.-8 a.m.	78
	18 Dec 76	8 a.m.-8 p.m.	Invalid data
	18-19 Dec 76	8 p.m.-8 a.m.	Invalid data
	19 Dec 76	8 a.m.-8 p.m.	Invalid data
	5-6 Jan 77	8 p.m.-8 a.m.	54
	6 Jan 77	8 a.m.-8 p.m.	136
	6-7 Jan 77	8 p.m.-8 a.m.	60
	7 Jan 77	8 a.m.-8 p.m.	56
	5-6 Apr 77	8 p.m.-8 a.m.	149
	6 Apr 77	8 a.m.-8 p.m.	124
	6-7 Apr 77	8 p.m.-8 a.m.	252
	7 Apr 77	8 a.m.-8 p.m.	398
2	17-18 Dec 76	8 p.m.-8 a.m.	107
	18 Dec 76	8 a.m.-8 p.m.	69
	18-19 Dec 76	8 p.m.-8 a.m.	60
	19 Dec 76	8 a.m.-8 p.m.	306
	5-6 Jan 77	8 p.m.-8 a.m.	59
	6 Jan 77	8 a.m.-8 p.m.	230
	6-7 Jan 77	8 p.m.-8 a.m.	63
	7 Jan 77	8 a.m.-8 p.m.	294
	5-6 Apr 77	8 p.m.-8 a.m.	79
	6 Apr 77	8 a.m.-8 p.m.	168
	6-7 Apr 77	8 p.m.-8 a.m.	209
	7 Apr 77	8 a.m.-8 p.m.	291
3	17-18 Dec 76	8 p.m.-8 a.m.	75
	18 Dec 76	8 a.m.-8 p.m.	87
	18-19 Dec 76	8 p.m.-8 a.m.	72
	19 Dec 76	8 a.m.-8 p.m.	70
	5-6 Jan 77	8 p.m.-8 a.m.	82
	6 Jan 77	8 a.m.-8 p.m.	189
	6-7 Jan 77	8 p.m.-8 a.m.	58
	7 Jan 77	8 a.m.-8 p.m.	92

TABLE 17. (Continued)

Sampling Site	Date	Time	Suspended particulates concentration, μg/m^3
	5-6 Apr 77	8 p.m.-8 a.m.	164
	6 Apr 77	8 a.m.-8 p.m.	149
	6-7 Apr 77	8 p.m.-8 a.m.	220
	7 Apr 77	8 a.m.-8 p.m.	564
4	17-18 Dec 76	8 p.m.-8 a.m.	30
	18 Dec 76	8 a.m.-8 p.m.	48
	18-19 Dec 76	8 p.m.-8 a.m.	75
	19 Dec 76	8 a.m.-8 p.m.	100
	5-6 Jan 77	8 p.m.-8 a.m.	75
	6 Jan 77	8 a.m.-8 p.m.	59
	6-7 Jan 77	8 p.m.-8 a.m.	52
	7 Jan 77	8 a.m.-8 p.m.	50
	5-6 Apr 77	8 p.m.-8 a.m.	106
	6 Apr 77	8 a.m.-8 p.m.	46
	6-7 Apr 77	8 p.m.-8 a.m.	143
	7 Apr 77	8 a.m.-8 p.m.	145
5	17-18 Dec 76	8 p.m.-8 a.m.	31
	18 Dec 76	8 a.m.-8 p.m.	47
	18-19 Dec 76	8 p.m.-8 a.m.	71
	19 Dec 76	8 a.m.-8 p.m.	45
	5-6 Jan 77	8 p.m.-8 a.m.	106
	6 Jan 77	8 a.m.-8 p.m.	86
	6-7 Jan 77	8 p.m.-8 a.m.	43
	7 Jan 77	8 a.m.-8 p.m.	46
	5-6 Apr 77	8 p.m.-8 a.m.	46
	6 Apr 77	8 a.m.-8 p.m.	49
	6-7 Apr 77	8 p.m.-8 a.m.	87
	7 Apr 77	8 a.m.-8 p.m.	69
8	17-18 Dec 76	8 p.m.-8 a.m.	39
	18 Dec 76	8 a.m.-8 p.m.	58
	18-19 Dec 76	8 p.m.-8 a.m.	63
	19 Dec 76	8 a.m.-8 p.m.	59
	5-6 Jan 77	8 p.m.-8 a.m.	76
	6 Jan 77	8 a.m.-8 p.m.	115
	6-7 Jan 77	8 p.m.-8 a.m.	62
	7 Jan 77	8 a.m.-8 p.m.	45

TABLE 17. (Continued)

Sampling Site	Date	Time	Suspended particulates concentration, $\mu g/m^3$
	5-6 Apr 77	8 p.m.-8 a.m.	85
	6 Apr 77	8 a.m.-8 p.m.	105
	6-7 Apr 77	8 p.m.-8 a.m.	98
	7 Apr 77	8 a.m.-8 p.m.	191
		24-Hour Samples	
6	17-18 Dec 76	8 p.m.-8 p.m.	33
	18-19 Dec 76	8 p.m.-8 p.m.	47
	5-6 Jan 77	8 p.m.-8 p.m.	76
	6-7 Jan 77	8 p.m.-8 p.m.	39
	5-6 Apr 77	8 p.m.-8 p.m.	28
	6-7 Apr 77	8 p.m.-8 p.m.	38
7	17-18 Dec 76	8 p.m.-8 p.m.	64
	18-19 Dec 76	8 p.m.-8 p.m.	88
	5-6 Jan 77	8 p.m.-8 p.m.	110
	6-7 Jan 77	8 p.m.-8 p.m.	48
	5-6 Apr 77	8 p.m.-8 p.m.	54
	6-7 Apr 77	8 p.m.-8 p.m.	67
9	17-18 Dec 77	8 p.m.-8 p.m.	33
	18-19 Dec 77	8 p.m.-8 p.m.	Invalid data
	5-6 Jan 77	8 p.m.-8 p.m.	45
	6-7 Jan 77	8 p.m.-8 p.m.	41
	5-6 Apr 77	8 p.m.-8 p.m.	39
	6-7 Apr 77	8 p.m.-8 p.m.	42
10	17-18 Dec 76	8 p.m.-8 p.m.	33
	18-19 Dec 76	8 p.m.-8 p.m.	57
	5-6 Jan 77	8 p.m.-8 p.m.	82
	6-7 Jan 77	8 p.m.-8 p.m.	41
	5-6 Apr 77	8 p.m.-8 p.m.	37
	6-7 Apr 77	8 p.m.-8 p.m.	57

TABLE 18. DATA PRESENTATION OF PARTICLE SIZING SAMPLER[(a)]

Stage	Percent in size range	Size range, microns
1	33.3	7.0 and above
2	13.2	3.3 - 7.0
3	5.9	2.0 - 3.3
4	3.4	1.1 - 2.0
Backup Filter	44.2	0 - 1.1

(a) Sampler was located at Site 3.

of refraction = 1.5150) and a cover slip were placed over the filter. The immersion oil matted the glass fibers in the pad and made them transparent.

Optical examinations were made with two instruments: (1) a Leitz microscope using transmitted light and (2) a Zeiss metallograph using reflected light either with dark-field or polarized-light illumination. All optical examinations were conducted at magnifications of approximately 500x.

Generally, the estimates of areas covered on the filter by coal and ash particles were made in 10 percent intervals, i.e., 0-10, 10-20, 20-30, etc., although for the Campaign I, broader ranges were used. An attempt was made to estimate the percentage of the tertiary category for Campaigns II and III by means of morphological and dark-field/polarized-light observations. The remaining areas of the filter remained uncovered.

Results of these microscope examinations for Campaigns I, II, and III are presented in Tables 19, 20, and 21.

TABLE 19. RESULTS OF OPTICAL EXAMINATION OF FILTER PADS, CAMPAIGN I

Location, time/date	Coal, % of area covered	Ash, % of area covered	Coal Particle Size Range, microns
1, Fri-8 p.m. 12-17-76	0-20	trace	10-40
1, Sat-8 a.m. 12-18-76	0-20	>trace	< 5-30
1, Sat-8 p.m. 12-18-76	0-20	>trace	< 5-20
1, Sun-8 a.m. 12-19-76	0-20	>trace	< 5-30/40
2, Fri-8 p.m. 12-17-76	0-20 (high side)	>trace	5-30
2, Sat-8 a.m. 12-18-76	0-20	>trace	5-40
2, Sat-8 p.m. 12-18-76	0-20 (low side)	1	< 5-20
2, Sun-8 a.m. 12-19-76	0-20	> 1	< 5-30
3, Fri-8 p.m. 12-17-76	0-20	trace	< 5-60/70
3, Sat-8 a.m. 12-18-76	0-20	0.5-1	5-40
3, Sat-8 p.m. 12-18-76	0-20	1	5-30
3, Sun-8 a.m. 12-19-76	0-20	trace	< 5-30
4, Fri-8 p.m. 12-17-76	0-20 (low side)	1-2	5-20
4, Sat-8 a.m. 12-18-76	0-20 (low side)	2-3	5-20
4, Sat-8 p.m. 12-18-76	0-20 (low side)	1-2	5-20
4, Sun-8 a.m. 12-19-76	0-20 (low side)	< 1	5-40

TABLE 19. (Continued)

Location, time/date	Coal, % of area covered	Ash, % of area covered	Coal Particle Size Range, microns
5, Fri-8 p.m. 12-17-76	< 1-2	0-20 (low to med)	5-10
5, Sat-8 a.m. 12-18-76	< 1-2	0-20 (low to med)	5-20
5, Sat-8 p.m. 12-18-76	2-3	0-20 (low to med)	5-15
5, Sun-8 a.m. 12-19-76	1-2	0-20 (low to med)	5-15
6, Fri-8 p.m. 12-17-76	1-2	0-20 (low to med)	5-15
6, Sat-8 p.m. 12-18-76	1-2	0-20 (med to high)	5-15
7, Fri-8 p.m. 12-17-76	1-3	0-20 (med to high)	5-20
7, Sat-8 p.m. 12-18-76	0-20 (low to med)	0-20 (low to med)	5-40
8, Fri-8 p.m. 12-17-76	1	0-20 (low to med)	5-15
8, Sat-8 a.m. 12-18-76	trace	0-20 (low to med)	5-15
8, Sat-8 p.m. 12-18-76	1-2	20-40 (low to med)	5-15
8, Sun-8 a.m. 12-19-76	< 1	0-20 (low to med)	5-15
9, Fri-8 p.m. 12-17-76	< 1	0-20 (low to med)	5-15/20

TABLE 19. (Continued)

Location, time/date	Coal, % of area covered	Ash, % of area covered	Coal Particle Size Range, microns
10, Fri-8 p.m. 12-17-76	< 1	0-20 (high side)	5-20
10, Sat-8 p.m. 12-18-76	< 1	20-40 (low side)	5-15/20

TABLE 20. RESULTS OF OPTICAL EXAMINATION OF FILTER PADS, CAMPAIGN II

Location, time/date	Coal, % of area covered$^{(a)}$	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns
#1-Pump House Wed. 8 p.m.-8 a.m. 1-5-77	0-10	<1	Trace	<5,20-30
#1 Thurs. 8 a.m.-8 p.m. 1-6-77	0-10	<1	Trace	<5,30-40 (some 100)
#1 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10	<1	Trace	<5,10-20 (some 40 & 50)
#1 Fri. 8 a.m.-8 p.m. 1-7-77	0-10	<1	Trace	<5,10-30 (some 40 & 50)
#2-Substation Wed. 8 p.m.-8 a.m. 1-5-88	0-10	<1	Trace	<5,10-20 (few larger)
#2 Thurs. 8 a.m.-8 p.m. 1-6-77	10-20 Low side <15	1-2	Trace	<5,10-20 (some larger)
#2 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10	2-3	Trace	<5,10-30 (few larger)
#2 Fr. 8 a.m.-8 p.m. 1-7-77	10-20	<1	Trace	<5,10-30 (some larger)
#3-Hamilton's Trailer Wed. 8 p.m.-8 a.m. 1-5-77	0-10	<1	Trace	<5,10-30 (some larger)
#3 Thurs. 8 a.m.-8 p.m. 1-6-77	0-10 High side >7	<1	Trace	<5,10-30
#3 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10	<1	Trace	<5,20-30 (some larger ones, ~100)
#3 Fri. 8 a.m.-8 p.m. 1-7-77	0-10	<1	Trace	<5-70
#4 Pen. Trailer Wed. 8 p.m.-8 a.m. 1-5-77	0-10	~1	Trace	<5-30

TABLE 20. (Continued)

Location, time/date	Coal, % of area covered[(a)]	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns
#4 Thurs. 8 a.m.-8 p.m. 1-6-77	0-10	<1	Trace	<5-30 (some larger ones, ~60)
#4 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10	<1	Trace	<5-30 (some larger)
#4 Fri. 8 a.m.-8 p.m. 1-7-77	0-10	<1	Trace	<5,30-40
#5-Ash Disposal Wed. 8 p.m.-8 a.m. 1-5-77	0-10	1-2	Trace	<5, 30 (some larger)
#5 Thurs. 8 a.m.-8 p.m. 1-6-77	0-10	<1	Trace	<5,30-40
#5 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10	<1	Trace	<5-20
#5 Fr. 8 a.m.-8 p.m. 1-7-777	0-10 Low side <5	<5	Trace	<5-20 (some larger)
#6 Schirf Farm[(b)] Wed. 8 p.m.-8 p.m. 1-5-77	0-10 Low <5	<1	Trace	<5-40 (some larger)
#6 Thurs. 8 p.m.-8 p.m. 1-6-77	0-10 Low <5	<1	Trace	<5-20 (few larger)
#7 Unit #3[(b)] Wed. 8 p.m.-8 p.m. 1-5-77	0-10	1-2	Trace	<5-30
#7 Thurs. 8 p.m.-8 p.m. 1-6-77	0-10	~1	Trace	<5-30
#8 Refuse Coal Area Wed. 8 p.m.-8 a.m. 1-5-77	0-10 Low <5	<1	Trace	<5,10-20
#8[(b)] Thurs. 8 a.m.-8 p.m. 1-6-77	0-10	1-2	Trace	<5-20

TABLE 20. (Continued)

Location, time/date	Coal, % of area covered[a]	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns
#8 Thurs. 8 p.m.-8 a.m. 1-6-77	0-10 Low <5	<1	Trace	<5-30 (few larger ones, 70)
#8 Fri. 8 a.m.-8 p.m. 1-7-77	0-10	<1	Trace	<5-30 (few larger)
#9 Pen. Recreation Area[b] Sat. 8 p.m.-8 a.m. 12-18-76	0-10 Low <5	3-4	Trace	<5,10-15
#9[b] Wed. 8 p.m.-8 p.m. 1-5-77	0-10 Low <5	1-2	Trace	<5-20
#9 Thurs. 8 p.m.-8 p.m. 1-6-77	0-10 Low <5	2-3	Trace	<5-10
#10 Stiles Farm[b] Wed. 8 p.m.-8 p.m. 1-5-77	0-10 Low <5	5-10	Trace	<5,10-15
#10 Thurs. 8 p.m. 1-5-77	0-10 Low <5	5-10	Trace	<5-20

(a) % reported is based upon an area/grid impact or % area of available filter pad.

(b) Filter subsequently used for chemical analysis.

TABLE 21. RESULTS OF MICROSCOPIC EXAMINATION OF GLASS-FIBER FILTER PADS, CAMPAIGN III

	Coal, % of area covered	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns	-Comments- Observed with transmitted light; dark field/polarized light
Sampler 1 Tues-8 p.m. 4-5-77	0-10	0-10	Trace	< 5-50 Some 200	
Sampler 1 Wed-8 a.m. 4-6-77	0-10	0-10	Trace	< 5-40 Few longer	
Sampler 1 Wed-8 p.m. 4-6-77	10-20 (low side)	0-10	Trace	< 5-40,50 Few larger	Soot
Sampler 1 Thurs-8 a.m. 4-7-77	10-20	0-10 (low side)	Trace	< 5-40,50 Some larger	
Sampler 2 Tues-8 p.m. 4-5-77	0-10	0-10	Trace	< 5-40	
Sampler 2 Wed-8 a.m. 4-6-77	10-20	0-10 (low side)	Trace	< 5-30 Few larger	Soot
Sampler 2 Wed-8 p.m. 4-6-77	0-10	10-20 (low side)	Trace	< 5-20,30 Few larger	Trace of soot
Sampler 2 Thurs-8 a.m. 4-7-77	0-10	10-20 (high side)	Trace	< 5-40,50	(Fly ash appears to be larger in size than usual.)
Sampler 3 Tues-8 p.m. 4-5-77	0-10 (high side)	0-10	Trace	< 5-50,70 Some larger	
Sampler 3 Wed-8 a.m. 4-6-77	0-10	0-10	Trace	< 5-20,30 Some larger	Soot
Sampler 3 Wed-8 p.m. 4-6-77	0-10 (high side)	0-10	Trace	< 5-30,50 Few larger	Soot
Sampler 3 Thurs-8 a.m. 4-7-77	10-20	0-10 (low side)	Trace	< 5-30,40 Some larger	Trace of soot

TABLE 21. (Continued)

	Coal, % of area covered	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns	-Comments- Observed with transmitted light; dark field/polarized light
Sampler 4 Tues-8 p.m. 4-5-77	0-10 (low side)	0-10	Trace	< 5-10,20 Few larger	
Sampler 4 Wed-8 a.m. 4-6-77	0-10 (low side)	0-10	Trace	< 5-20,30	
Sampler 4 Wed-8 p.m. 4-6-77	0-10	0-10	Trace	< 5-20,30 Some larger	
Sampler 4 Thurs-8 a.m. 4-7-77	10-20	0-10 (low side)	Trace	< 5-30,50 Some larger	
Sampler 5 Tues-8 p.m. 4-5-77	0-10 (low side)	0-10		< 5-10,20 Few larger	
Sampler 5 Wed-8 a.m. 4-6-77	0-10 (low side)	10-20 (med range)	Trace	< 5-20,30 Few larger	
Sampler 5 Wed-8 p.m. 4-6-77	0-10	10-20 (low side)	Trace	< 5-20,30	
Sampler 5 Thurs-8 a.m. 4-7-77	0-10	0-10 (high side)	Trace	< 5-30,40 Some larger	
Sampler 6 Tues-8 p.m. 4-5-77	0-10 (low side)	0-10 (high side)	Trace	< 5,10-20 Few larger	
Sampler 7 Tues-8 p.m. 4-5-77	0-10 (low side)	0-10	Trace	< 5-20 Some larger	Small metallic particles; silica particles
Sampler 7 Wed-8 p.m. 4-6-77	0-10	0-10	Trace	< 5-20,30 Few larger	
Sampler 8 Tues-8 p.m. 4-5-77	0-10 (low side)	0-10 (low side)		< 5-10,20 Some larger	
Sampler 8 Wed-8 a.m. 4-6-77	0-10 (very low) ~1%	0-10	Trace	< 5-15 Few larger	

TABLE 21. (Continued)

	Coal, % of area covered	Ash, % of area covered	Tertiary, % of area covered	Coal Particle Size Range, microns	-Comments- Observed with transmitted light; dark field/polarized light
Sampler 8(1) Wed-8 p.m. 4-6-77	0-10	10-20 (low side)	Trace	< 5-20,30 Few larger	Some soot
Sampler 8(2) Wed-8 p.m. 4-6-77	0-10	10-20 (low side)	Trace	< 5-20,30 Few larger	Some soot
Sampler 8 Thurs-8 a.m. 4-7-77	0-10 (high side)	0-10	Trace	< 5-20,30 Quite a few larger	Few whites
Sampler 9 Tues-8 p.m. 4-5-77	0-10 (very low)	0-10 (high side)	Trace	< 5-10 Some larger	
Sampler 9 Wed-8 p.m. 4-6-77	0-10	0-10 (high side)	Trace	< 5-20 Some larger	
Sampler 10 Tues-8 p.m. 4-5-77	0-10 (very low)	0-10 (high side)	Trace	< 5-15 Few larger	
Sampler 10 Wed-8 p.m. 4-6-77	0-10	10-20	Trace	< 5-30 Some larger	

Trace Elements Analysis

Analytical Procedures.

Filter Preparation. The clean margin area was trimmed from each filter and the trimmed filter was weighed. It was then divided as equally as possible into eight pieces, each of which was weighed. The calculations from the individual analysis to the milligram values for the entire filter were then done on a weight proportion basis. A blank filter was treated and analyzed in the same manner and the blank values were included in the final calculations.

Chlorine Analysis (Based on ASTM D2361-66). One-eighth filter was cut into 1-inch-square portions and layered into a crucible with 2.5 g of Eschka mixture. The crucible was heated to 675 C within 1 hour and maintained at that temperature for 1-1/2 hours. The mixture was cooled, dissolved in a solution containing 8 ml nitric acid, diluted to 100 ml, and filtered. The chloride was titrated potentiometrically using 0.01 N $AgNO_3$ and a Beckman Automatic Titrator.

Fluorine Analysis (Based on Preparation Used in ASTM D2361-66). One-eighth filter was cut into 1-inch-square portions and layered into a crucible with 2.5 g of Eschka mixture. The crucible was heated to 675 C within 1 hour and maintained at that temperature for 1-1/2 hours. The mixture was cooled and then dissolved in a solution containing 8 ml of sulfuric acid. This solution was diluted to 100 ml. The fluoride was measured using an Orion electrode and specific ion meter after distillation according to Standard Methods for the Examination of Water and Wastewater, 14th edition.

Total Organic Carbon (TOC) Analysis. One-eighth filter was placed in a Petri dish, covered with 5 ml of 1N HCl, and then placed in an oven at 103 C and evaporated to dryness to remove the inorganic carbon. The dried filter portions were cut into small strips and placed in a Leco combustion boat. The Petri dishes were washed with 2 ml of deionized water and the washings were added to the boats, which were again dried at 103 C. Standard organic carbon solutions were pipetted into combustion boats and dried in the same manner. The individual boats were fired in a stream of oxygen in a Leco-tube-type resistance furnace. The gas stream from the combustion tube was scrubbed into a 50-ml solution of 0.10 N NaOH. These solutions were diluted to 100 ml; 30 μl of each solution and standard was injected into the total carbon channel of a Beckman 914 TOC Analyzer.

Metals Analysis. The following procedures have been used successfully for the NBS coal standard SRM1632:

(1) Mercury. One-eighth filter was cut into strips and placed on edge in a combustion boat. It was fired in a Leco resistance furnace using an oxygen stream to carry the volatilized mercury to a scrubber containing acidic permanganate and persulfate. Standards and reagent blanks were prepared in the same manner. The scrubber solution was reduced and bubbled with nitrogen through an LDC Mercury Monitor.

(2) Arsenic. One-eighth filter was placed in an Erlenmeyer flask covered by a watch glass. A solution containing 2 ml of $HClO_4$, 2 ml of H_2SO_4, and 1 mg of vanadium catalyst was added and the flasks were slowly heated through the entire boiling range of perchloric acid until the particulates turned white or colorless. The solution was cooled and the watch glass was washed into the Erlenmeyer flask. The solution was diluted and analyzed by the silver diethyldithiocarbamate chlorimetric method given in Standard Methods for the Examination of Water and Wastewater, 13th edition.

(3) All other metals. One-eighth filter was placed in a Teflon beaker; HCl, HNO_3, and HF were added, and the solution was slowly heated to dryness. Perchloric acid was added, the beaker covered by a watch glass, and heated until the remaining material was digested. One ml of HNO_3 was added to the solutions and they were diluted to 50 ml and analyzed using a Perkin Elmer 503 Atomic Absorption Spectrophotometer.

General Chemical Analysis Procedure.

Campaign I. The chemical analysis of the hi-vol filter pads was designed for coal or ash analysis, since these are assumed to comprise a significant portion of the particulate, particularly the 12-hour samples. Data from the microscopic analysis of the filters were used to determine which filters would be analyzed for trace elements. Generally, the filter exhibiting the highest percentage of coal or ash from each site was selected.

Each candidate filter was analyzed for the following elements in Campaign I:

Arsenic
Beryllium
Cadmium
Calcium
Chromium
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Sodium
Zinc
Total Organic Carbon
Chloride
Fluoride

Blank filters were analyzed in conjunction with the other filters. The filter-blank values were then subtracted from the total values. The blank filter was analyzed in duplicate for metal. These duplicate analyses were in precise agreement with each other. Only traces of iron, copper, manganese, chromium, zinc, mercury and lead were found. However, large amounts of sodium, potassium, calcium, and magnesium were found in the blank filters as shown below.

Sodium (Na)	320	311 milligrams/filter
Potassium (K)	304	284 milligrams/filter
Calcium (Ca)	250	243 milligrams/filter
Magnesium (Mg)	68	68 milligrams/filter

When these values are compared with the quantities of metals that we are trying to measure it is apparent that the relative error makes the results for these four metals meaningless. Therefore these metals were not reported in Campaign I.

Beryllium content was below the minimum detection limits at each of the ten sites.

Campaign II. Antimony, titanium, and vanadium were included in the elemental analysis for Campaign II; calcium, magnesium, potassium, and sodium were not analyzed because of their high concentrations in the blank filters.

Beryllium, vanadium, and antimony were below the minimum detectable limits; titanium was observed at only two of the ten sites.

Campaign III. A new filter, Spectrograde Type A glass fiber, made by Gelman Instrument Company, was used in Campaign III.

The new fiber glass filters still showed large amounts of calcium, magnesium, potassium, and sodium. Therefore, analyses for these metals were not made on the other filters. Also, the new filters showed larger amounts of zinc, chloride, and fluoride than did the previous filters.

The chloride analysis of the blank was high, the value being 2-1/2-to-3 times higher than the total values (blank included) for the filters in Campaigns I and II. Therefore, no chloride values were reported in this campaign. Selenium was analyzed in this campaign using neutron activation analysis. Blank analyses of filters used in Campaigns II and III are given in Tables 22 and 23, respectively.

Chemical analyses of particle size distribution samples were run on the four stages and the backup filter. These results are reported in Table 24.

TABLE 22. BLANK ANALYSIS OF FILTER USED IN CAMPAIGN II

Parameter	Milligrams
Antimony	<0.1
Arsenic	0.022
Beryllium	<0.004
Cadmium	0.018
Chromium	0.023
Copper	0.36
Iron	2.0
Lead	1.2
Manganese	0.043
Mercury	0.00013
Nickel	0.0040
Titanium	<0.2
Vanadium	<0.1
Zinc	0.16
TOC	21.5
Fluoride	1.8
Chloride	0.71

TABLE 23. BLANK ANALYSIS OF FILTER USED IN CAMPAIGN III

Parameter	Milligram per filter
Arsenic	<0.002
Beryllium	<0.004
Cadmium	<0.0010
Calcium	86
Chromium	0.053
Copper	0.016
Iron	1.72
Lead	0.020
Magnesium	33.1
Manganese	0.075
Mercury	0.000053
Nickel	<0.010
Potassium	31.1
Titanium	.25
Selenium	5.3
Sodium	235
Zinc	1.95
Vanadium	< .05
TOC	4.0
Chloride	11.0
Fluoride	19.3

TABLE 24. TRACE ELEMENT ANALYSIS OF THE PARTICLE SIZING SAMPLER USED AT SITE 3, CAMPAIGN III

Stage	Size range, microns	Percent loading in size range	Concentration, ppm by weight of particulates															
			As	Cd	Ca	Cr	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Sc	Zn	Ti	V
1	(7.0 and above)	33.3	23.76	(a)	12,544.56	(a)	132	15,077.8	237.68	3376.86	198.07	3.03	39.6	1621.68	(b)	171.7	1585.0	(a)
2	(3.3-7.0)	13.2	53.14	(a)	9631.4	265.7	299	14,613.1	498.2	2324.8	166.1	7.3	99.6	3985.4	(b)	(a)	1860.0	(a)
3	(2.0-3.3)	5.9	118.51	(a)	12,592.6	(a)	666.6	15,555.6	888.9	5185.2	296.3	11.9	(a)	7407.4	(b)	(a)	--	(a)
4	(1.1-2.0)	3.4	104.6	(a)	2614.4	307.2	2222.2	14,379.1	2614.4	(a)	392.16	11.63	130.7	5228.8	(b)	8104.6	(a)	(a)
Back-up Filter	(0-1.1)	44.2	78.4	10.9	(b)	89.3	46.7	9627.8	2084.4	(b)	228.3	(a)	(a)	(b)	66.5	2580.6	(a)	(a)

(a) Below minimum detectable limit.
(b) Element not analyzed.

In order to provide a general indication of the trace element level encountered, brief summaries have been prepared. However, these summaries are insufficient to establish a sufficient data base. The average values for 12-hour and 24-hour samples, as well as minimum and maximum levels for each time frame, are given in Table 25. The average values for Campaigns I, II, and III for selected sites are given in Table 26. These sites are generally in a line from the coal pile at distances of 175 to approximately 2200 meters. Site 6 is off property and generally not affected by emissions from the coal piles or power plant stacks and therefore serves as a background or control site.

The trace element concentrations as they relate to mass concentration ranges are shown in Table 27. Data in this table indicate that trace element concentration is not always directly proportional to the mass concentrations.

Trace element concentrations in ppm by weight of particulate matter captured on the filter pads are shown in Table 28.

Chemical Analysis of Coal

Coal Source. The Homer City power plant receives its coal from three sources, namely the Helen mine, Helvetia mine, and trucked-in coal (Josephine). The Helen and Helvetia mines are part of the Upper Freeport Seam, while the trucked-in coal is from the Lower Kittanning Seam.

Analytical Procedures. Samples of the coals were air-dried, pulverized to -60 mesh, split with an enclosed riffle, placed in glass jars, and mixed on a blending wheel for 1/2 hour.

Routine analyses were carried out by the following methods:

Analysis	ASTM Method
% Moisture	D3173-73
% Ash	D3174-73
% Sulfur	D3177-75
Btu	D2015-66 (1972)
Fixed Carbon	D3172-73
Carbon	D3175-73
Hydrogen	D3178
Nitrogen	D3179

TABLE 25. COMPARISON BETWEEN TRACE ELEMENT CONCENTRATIONS IN 12- AND 24-HOUR SAMPLES

	Concentrations, $\mu g/m^3$														
	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti(a)	Zn	Cl(b)	F	V(c)	Se(d)
	12-Hour Samples														
Average Arithmetic	0.14	.009	.0261	0.217	3.56	0.442	.088	.00017	.018	0.58	0.30	1.45	2.56	—	.0046
Maximum	.053	.039	.064	0.484	16.55	1.50	.804	.00041	.028	1.53	0.70	3.40	7.48	.06	.0088
Minimum	.005	.001	.007	0.011	1.04	0.160	.031	.00002	.006	0.58	0.08	0.20	0.20	—	.0002
	24-Hour Samples														
Average Arithmetic	.011	.006	.015	0.189	1.88	0.308	.036	.00005	.008	0.14	0.13	1.84	1.36	—	.0041
Maximum	.022	.020	.022	0.310	0.80	0.500	.063	.00010	.018	0.17	0.21	1.92	2.40	.02	.0051
Minimum	.002	.001	.007	0.112	1.40	0.144	.022	.00002	.001	0.09	0.06	0.19	0.40	—	.0031

(a) For Campaigns II and III only; titanium was recorded above the minimum detection limit twice in Campaign II.

(b) For Campaigns I and II only.

(c) For Campaign III only; vanadium was recorded above the minimum detection limits at only two sites.

(d) For Campaign III only.

TABLE 26. COMPARISON BETWEEN TRACE ELEMENT CONCENTRATIONS AT SELECTED SITES (CAMPAIGNS I, II, AND III)

Site	Distance from coal pile, meters	Concentrations, µg/cu m														
		As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	Zn	Cl	F	V	Se
1	(175)	.015	.006	.027	0.184	3.65	0.529	0.058	.00087	.014	0.71	0.41(e)	0.95(a)	7.48	(b)	.0051
3	(150)	.014	.011	.026	0.400	3.25	0.644	0.095	.00024	.016	0.18	0.33	2.31	3.46	(b)	.0047
4	(400)	.011	.005	.014	0.146	2.22	0.228	0.217	.00008	.018	0.33	0.28	0.98	2.0	(b)	.0026
8	(800)	.011	.016	.017	0.045	1.81	0.498	0.026	.00013	.007(a)	0.46(a)	0.25	0.73	2.53	(b)	.0002(a)
9	(1800)	.007	.007	.015	0.165	1.57	0.277	0.036	.00005	.011	0.13(a)	0.12	0.74	1.56	(b)	.0051(a)
10	(2200)	.015	.008	.014	0.174	1.99	0.350	0.034	.00008	.006	0.17(a)	0.10	0.58(a)	0.67	(b)	.0049(a)
6(c)	(1600)	.009	.005	.014	0.223	1.65	0.258	0.041	.00003	.009	0.17(a)	0.13	1.05	1.40	.02(a)	.0030(a)

(a) One observed value.
(b) Below minimum detectable limit.
(c) Site 6 is off property and serves as a background site.

TABLE 27. TRACE ELEMENT CONCENTRATIONS AS THEY RELATE TO MASS CONCENTRATION RANGES FOR ALL SITES AND ALL CAMPAIGNS

Mass Concentration Range, ug/m^3	No. of Samples	Concentrations, µg/m^3														
		As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	Zn	Cl	F	V	Se
							12-Hour Samples									
0-50	5	.007	.030	.022	.089	2.20	.320	.046	.00014	.050	(b)	.26	2.80	3.5	(b)	(c)
	4	.005	.003	.019	.011	1.24	.285	.034	.00005	.008	(a)	.08	1.14	2.28	(a)	(c)
51-100	5	.017	.002	.023	.163	2.79	.500	.052	.00015	.006	(a)	.10	3.27	.39	(a)	(c)
	8	.015	.039	.020	.050	2.20	.810	.034	.00012	(a)	(b)	.20	1.10	2.20	(b)	(b)
	8	.012	.007	.016	.040	1.04	.351	.031	.00013	.007	(a)	.22	.36	2.49	(a)	(c)
	5	.015	.021	.021	.230	2.40	.730	.046	.00014	(a)	(b)	.29	.20	.20	(b)	(b)
	4	.011	.012	.013	.084	1.70	.280	.029	.00017	.027	(b)	.20	.82	1.50	(b)	(c)
	3	.008	.023	.020	.320	2.50	1.50	.055	.00025	.028	(b)	.31	3.40	3.30	(b)	(c)
	5	.019	.004	.020	.357	2.98	.160	.061	.00009	.021	.040	.38	(c)	2.0	(a)	.0079
101-150	2	.006	(a)	.060	.130	1.80	.230	.060	.00016	.020	(b)	.25	1.50	2.5	(b)	(c)
	1	.021	.006	.064	.243	2.56	.598	.071	.00041	.007	1.18	.41	.95	7.48	(a)	(c)
	4	.018	.003	.016	.196	3.94	.167	.804	(a)	(a)	.39	.41	(c)	2.41	(a)	.0048
	4	.009	.002	.007	.293	2.00	.180	.0009	.00002	(a)	.27	.41	(c)	1.81	(a)	.0004
151-200	3	.024	.005	.043	.484	3.13	.585	.101	.00013	.014	(a)	.43	1.21	3.63	(a)	(c)
	8	.006	.002	.014	.045	2.19	.333	.014	(a)	(a)	.46	.320	(c)	2.90	(a)	.0002
201-250	2	.053	.005	.045	.437	8.09	.614	.093	.00023	.021	.58	.41	.93	1.58	(a)	(a)
	3	.017	.005	.018	.475	3.86	.207	.063	.00038	.010	.046	(a)	(c)	(a)	(a)	.0071
251-300	2	.007	.001	.041	.246	3.88	.369	.058	.00012	.010	(a)	.11	1.23	3.41	(a)	(b)
	1	.019	.005	.011	.175	4.60	.558	.076	.00013	.020	.49	(a)	(c)	(a)	(a)	.0066
	2	.025	.002	.053	.340	16.55	.240	.124	.00026	.026	1.53	.70	(c)	(a)	.06	.0088
301-450	1	.006	(a)	.007	.134	3.8	.432	.026	.00007	(a)	.45	(a)	(c)	(a)	(a)	.0035
451-600	3	.006	(a)	.021	.323	3.5	.282	.045	.0002	.013	.35	.26	(c)	(a)	(a)	.0023
							24-Hour Samples									
0-50	6	.011	.010	.014	.180	1.40	.320	.028	.00002	.013	(b)	.09	1.92	1.69	(b)	(b)
	9	.006	.013	.022	.200	1.90	.420	.060	.00007	.018	(b)	.17	.90	1.4	(b)	(b)
	9	.008	-	.016	.112	1.41	.268	.026	.00003	.003	(a)	.06	.58	1.75	(a)	(b)
	6	.002	.0026	.011	.310	1.64	.145	.039	.00002	.008	.17	.21	(c)	.83	.02	.0030
	9	.006	.0008	.007	.183	1.40	.144	.022	.00004	(a)	.13	(a)	(c)	(a)	(a)	.0051
51-100	6	.015	.003	.016	.178	1.92	.310	.056	.00005	.007	(a)	.09	.19	1.69	(a)	(b)
	7	.007	.012	.020	.230	1.80	.340	.055	.00002	.001	(b)	.14	1.30	2.4	(b)	(b)
	10	.013	.020	.013	.230	1.90	.500	.026	.00008	.010	(b)	.17	.58	.94	(b)	(b)
	10	.022	.003	.020	.163	2.04	.373	.041	.00006	.002	(a)	.13	(a)	.40	(a)	(b)
	10	.011	.001	.010	.129	2.02	.178	.035	.0001	.007	.17	(a)	(c)	(a)	(a)	.0049
	7	.009	.002	.010	.215	2.80	.210	.048	.00005	.007	.09	(a)	(c)	(a)	(a)	.0033
101-150	7	.021	.003	.022	.137	2.34	.488	.063	.00006	.011	(a)	.15	.42	1.12	(a)	(b)

(a) Below minimum detectable limits.
(b) Trace element was analyzed in this campaign.
(c) Value not reported due high concentrations in the blank filter.

TABLE 28. TRACE ELEMENT CONCENTRATION OF PARTICULATE ON THE FILTER PAD

Site	Campaign	Sampling period, hours	Particulate concentration, μg/m^3	Trace Element Concentration, ppm by weight														
				As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ti	V	Zn	F	Cl	Se
1	II	12	136	154	44	471	1,787	18,824	4,397	523	3	51	8,676	(a)	3,015	55,000	6,985	6
1	III	12	252	74	18	43	695	18,281	2,215	304	1	78	1,954	(a)	(a)	(a)	(c)	26
1	III	12	398	15	(a)	18	336	9,557	1,085	65	.2	(a)	1,135	(a)	(a)	(a)	(c)	9
2	I	12	107	56	(a)	561	1,215	16,822	2,150	561	1	187	(b)	(b)	2,336	23,364	14,019	(b)
2	II	12	230	230	22	196	1,900	35,174	2,670	404	1	91	2,522	(a)	1,783	6,870	4,043	(b)
2	II	12	294	24	3	139	837	13,197	1,255	197	.4	34	(a)	(a)	374	11,599	4,184	(b)
2	III	12	291	85	7	182	1,168	56,962	826	427	1	88	5,269	199	2,421	(a)	(c)	30
3	I	12	87	92	264	230	3,678	28,736	17,241	632	3	264	(b)	(b)	3,563	37,931	39,081	(b)
3	II	12	189	127	26	228	2,561	16,561	3,095	534	1	74	(a)	(a)	2,275	19,206	6,402	(b)
3	III	12	220	76	24	81	2,154	17,501	942	287	2	45	2,109	(a)	—	(a)	(c)	33
3	III	12	564	11	(a)	38	572	6,223	501	81	.4	23	626	(a)	465	(a)	(c)	4
4	I	12	100	110	120	130	840	17,000	2,800	2,400	2	270	(b)	(b)	2,000	15,000	8,200	(b)
4	II	12	50	100	60	380	220	24,800	5,700	680	(a)	160	(a)	(a)	1,600	45,600	22,800	(b)
4	III	12	143	130	21	109	1,367	27,468	1,162	5,603	(a)	(a)	2,733	(a)	2,870	16,809	(c)	33
4	III	12	145	65	10	46	2,016	13,718	1,235	6	1	(a)	1,885	(a)	2,796	12,483	(c)	3.0
5	I	12	47	149	638	468	1,894	46,809	6,809	979	1	1,064	(b)	(b)	5,532	53,191	59,574	(b)
5	I	12	71	211	296	296	3,239	33,803	10,282	648	2	(a)	(b)	(b)	4,085	42,553	42,553	(b)
5	II	12	106	160	19	217	1,538	26,321	4,717	491	1	57	(a)	(a)	943	3,679	30,849	(b)
5	III	12	87	217	45	206	4,126	34,419	1,846	706	1	239	4,560	(a)	4,343	23,127	(c)	91
8	I	12	63	238	619	317	794	34,921	12,857	540	2	(a)	(b)	(b)	3,175	34,921	17,460	(b)
8	II	12	62	194	113	258	645	16,774	566	500	2	113	(a)	(a)	3,548	40,161	5,806	(b)
8	III	12	191	34	12	74	235	11,477	1,745	74	(a)	(a)	2,416	(a)	1,678	15,235	(c)	1
6	I	24	33	333	303	424	5,455	42,424	9,696	848	1	394	(b)	(b)	4,848	1,818	10,000	(b)
6	II	24	76	197	39	211	2,342	25,263	4,079	737	1	92	(a)	(a)	1,184	22,237	2,526	(b)
6	III	24	38	52	67	285	7,957	42,637	3,801	974	1	202	4,513	594	5,463	21,496	(c)	77
7	I	24	64	109	187	313	3,594	28,125	5,312	859	.3	16	(b)	(b)	2,188	37,500	20,313	(b)
7	II	24	110	190	27	200	1,245	21,273	4,436	573	1	100	(a)	(a)	1,364	10,182	3,818	—
7	III	24	67	136	31	143	3,211	34,106	3,140	714	1	107	1,356	(a)	(a)	(a)	(c)	49
9	I	24	33	181	393	667	6,061	57,576	12,727	1,818	2	545	(b)	(b)	5,152	42,424	27,278	(b)
9	II	24	45	177	(a)	356	2,489	31,333	5,955	578	1	67	(a)	(a)	1,333	38,889	12,889	(b)
9	III	24	42	135	19	166	4,356	33,392	3,422	529	1	(a)	3,007	(a)	(a)	(a)	(c)	122
10	I	24	57	228	351	228	4,035	33,333	8,772	456	1	175	(b)	(b)	2,982	16,491	10,175	(b)
10	II	24	82	268	37	244	1,988	24,878	4,545	500	1	24	(a)	(a)	1,585	4,879	(a)	(b)
10	III	24	57	191	23	173	2,252	35,433	3,119	615	2	121	2,946	(a)	(a)	(a)	(c)	86

(a) Below minimum detectable limits.
(b) Element not analyzed.
(c) Element not reported because of high background concentration in blank filter.

Chlorine	D2361-66	
Oxygen	D3176-74	
Sulfur Forms	D2498-68	(1974)

Fluorine. The coal was fired in an oxygen bomb containing a small quantity of one normal sodium hydroxide. The bomb contents and washing were then analyzed by the method of known addition using a fluoride-specific ion probe.

Mercury. Coal samples were fired in a resistance furnace using an oxygen gas stream to carry the volatilized mercury to an acidic permanganate-persulfate scrubber solution. This solution was then analyzed for mercury using flameless atomic absorption spectrophotometry.

Arsenic. Samples were digested using a mixture of perchloric acid, sulfuric acid, and vanadium catalyst; the arsenic was determined colorimetrically using the silver diethyldithiocarbamate method.

Selenium. Neutron activation.

Other Metals. 0.5 gram samples of coal were ashed by bringing the temperature to 500 C over one hour and then to 750 C over a second hour. The ash was washed into Teflon beakers and dried. HF (4 ml) was added and the samples taken to dryness. A solution containing 0.5 ml HCl and 1 ml HNO_3 was added and the solutions heated to expel chlorine and solubilize the residue. The solutions were diluted to 50 ml and analyzed by atomic absorption spectrophotometry using reagent blanks and standards in the same acid matrix. NBS standard 1632 was analyzed in conjunction with these samples and excellent agreement was found with all metals except vanadium. The NBS certified value for vanadium is 35 ± 3 ppm; our analysis value was 50 ppm. (An ASTM draft procedure shows that four laboratories analyzed NBS 1632 in quadruplicate by a procedure similar to the one above. They found good agreement with NBS values except for vanadium; their average value was 45.7 ± 4 ppm.)

Results. The composition and trace elements contents of the coals from all three sources are given in Tables 29 through 34.

TABLE 29. COAL ANALYSIS (HELEN MINE)

	As Received, %[a]	Dry Basis, %[a]
Moisture	2.58	—
Ash	23.68	24.31
Sulfur	2.94	3.02
Btu	11,274	11,573
Fixed carbon	50.41	51.75
Volatile matter	23.32	23.94
MAF Btu[b]	-	15,290
Carbon	63.00	64.67
Hydrogen	4.02	4.13
Nitrogen	1.10	1.13
Chlorine	0.25	0.26
Oxygen	2.42	2.48
Sulfur Forms:		
Pyritic	2.45	2.51
Sulfate	0.09	0.09
Organic	0.41	0.42

(a) Btu measurements are not given in percentages.
(b) MAF = moisture- and ash-free.

TABLE 30. TRACE ELEMENT ANALYSIS (HELEN MINE)

	μg/g	
	As Received	Dry Basis
Aluminum	26,700	27,420
Antimony	<25	<25
Arsenic	26	27
Barium	102	105
Beryllium	2.5	2.6
Cadmium	<0.1	<0.1
Calcium	3,000	3080
Chromium	35	36
Cobalt	15	15
Copper	26	27
Iron	27,600	28,350
Lead	12.0	12.3
Magnesium	1,470	1,510
Manganese	63	65
Mercury	0.46	0.47
Nickel	15.8	16.2
Titanium	1,165	1,200
Vanadium	60	62
Zinc	46	47
Fluorine	98	101

TABLE 31. COAL ANALYSIS (HELVETIA MINE)

	As Received, %(a)	Dry Basis, %(a)
Moisture	3.97	—
Ash	22.44	23.37
Sulfur	1.91	1.99
Btu	11,277	11,743
Fixed carbon	49.80	51.86
Volatile matter	23.79	24.77
MAF Btu(b)	—	15,324
Carbon	63.29	65.91
Hydrogen	4.32	4.50
Nitrogen	1.13	1.18
Chlorine	0.26	0.27
Oxygen	2.91	3.03
Sulfur Forms:		
Pyritic	1.44	1.50
Sulfate	0.03	0.03
Organic	0.44	0.46

(a) Btu measurements are not given in percentages.
(b) MAF = moisture- and ash-free.

TABLE 32. TRACE ELEMENT ANALYSIS (HELVETIA MINE)

	μg/g(a)	
	As Received	Dry Basis
Aluminum	28,050	29,200
Antimony	<25	<25
Arsenic	22	23
Barium	116	121
Beryllium	2.5	2.6
Cadmium	<0.1	<0.1
Calcium	1520	1580
Chromium	33	34
Cobalt	14	15
Copper	31	32
Iron	18,000	18,740
Lead	14.9	15.5
Magnesium	1345	1400
Manganese	35	36
Mercury	0.34	0.35
Nickel	16.8	17.5
Titanium	1125	1170
Vanadium	65	68
Zinc	66	69
Fluorine	108	112
Selenium	—	2.9∓.6 (a)

(a) Selenium given in parts per million.

TABLE 33. COAL ANALYSIS (TRUCKED-IN COAL)

	As Received, %(a)	Dry Basis, %(a)
Moisture	3.00	—
Ash	24.52	25.28
Sulfur	5.67	5.85
Btu	11,037	11,378
Fixed carbon	50.99	52.57
Volatile matter	21.49	22.15
MAF Btu (b)	—	15,228
Carbon	60.94	62.82
Hydrogen	3.95	4.07
Nitrogen	1.12	1.15
Chlorine	0.23	0.24
Oxygen	0.57	0.59
Sulfur Forms:		
Pyritic	4.95	5.10
Sulfate	0.15	0.16
Organic	0.57	0.59

(a) Btu measurements are not given in percentages.
(b) MAF = moisture- and ash-free.

TABLE 34. TRACE ELEMENT ANALYSIS (TRUCKED-IN COAL)

	μg/g(a)	
	As Received	Dry Basis
Aluminum	25,300	26,080
Antimony	<25	<25
Arsenic	48	49
Barium	250	258
Beryllium	2.5	2.6
Cadmium	0.26	0.27
Calcium	760	784
Chromium	30	31
Cobalt	14	14
Copper	20	21
Iron	48,750	50,260
Lead	17.3	17.8
Magnesium	975	1005
Manganese	74	76
Mercury	1.1	1.1
Nickel	12.8	13.2
Titanium	1329	1370
Vanadium	55	57
Zinc	64	66
Fluorine	91	94
Selenium	—	6.4(±1.2) (a)

(a) Selenium given in parts per million.

Statistical Analysis

Purpose. A statistical analysis is necessary because the measurements of concentrations are subjected to processes which cause fluctuations, or variations in the measurements. Wind direction, wind speed, distance, and types of measurements all contribute to the observed variations.

As a result, the average value of a small set of samples is likely not to be the true mean value. Thus, if one took samples one day under a certain set of conditions and took samples another day under identical conditions, the means of the samples would be different, although they would be expected to be identical.

For the same reason, if the means could be expected to be different, they might coincidentally turn out to be identical.

It is therefore necessary to use the variation within the samples to determine the tolerance in the estimated value of the sample mean. Such a procedure is conducted in an analysis of variance.

Analysis of Variance--Background and Approach. The purpose of the analysis of variance is to test whether the mean of a group of samples (i.e., samples of trace element concentrations) differs significantly from the mean of another group of samples measured under different conditions. In essence, the data are examined to determine whether the effect of a set of conditions (day/night, or site location) is real or likely to have arisen as a result of random variation. The normal statistical assumptions have been made to permit this analysis: concentrations of trace elements and total mass represent random samples independent of each other; and all variations have normal distributions.

Data used in the analysis are shown in Tables 17 and 18 presented in the section on particulate concentrations. The trace elements studied in this analysis are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), zinc (Zn), fluoride (F), and chlorine (Cl).

Four hypotheses were considered in the analysis: (1) the means of sample concentrations for a particular element are identical at all sampling sites; (2) the concentration means of sample groups, Sites 1 and 3, 4 and 5, 8 and 9, for a particular element are identical; (3) the concentration means of the 24-hour samples, 12-hour day samples, and 12-hour night samples are identical; and (4) the 12-hour day and 12-hour night samples are identical.

The levels of confidence with which a particular hypothesis is rejected are expressed as a percentage. The hypothesis is stated in the table caption (see Tables 35-38). With a level of confidence of 90 percent or greater, the hypothesis may be rejected as not true. A level of confidence that is less than 90 percent indicates that the data for the particular element contain a significant amount of random fluctuations as opposed to systematic fluctuations. Therefore, the stated hypothesis may not be rejected.

A discussion of the outcome of these hypotheses follows in the order just stated.

TABLE 35. HYPOTHESIS THAT THE MEANS OF THE SAMPLES AT EACH SAMPLING SITE ARE IDENTICAL

Element	Level of confidence (%) with which hypothesis is rejected (a)
Total Mass	*99
Arsenic	*90
Cadmium	33
Chromium	40
Copper	*99+
Iron	*92
Lead	34
Manganese	76
Mercury	60
Nickel	74
Zinc	50
Fluoride	30
Chloride	75

*Denotes a level of confidence high enough to reject the hypothesis.

(a) Values in table are rounded to nearest integer.

TABLE 36. HYPOTHESIS THAT THE MEANS OF THE SAMPLES AT SITES 1 AND 3 ARE IDENTICAL TO THOSE AT SITES 4 AND 5, AND SITES 8 AND 9

Element	Level of confidence (%) with which hypothesis is rejected[(a)]
Total Mass	*99+
As	*96
Cd	60
Cr	68
Cu	29
Fe	*92
Pb	52
Mn	79
Hg	69
Ni	69
Zn	60
F	51
Cl	60

*Denotes a level of confidence high enough to reject the hypothesis.

(a) Values in table rounded to nearest integer.

TABLE 37. HYPOTHESIS THAT THE MEANS OF THE FOLLOWING SAMPLE GROUPS ARE IDENTICAL: 24-HOUR SAMPLES, 12-HOUR DAY SAMPLE, AND 12-HOUR NIGHT SAMPLE

Element	Level of confidence (%) with which hypothesis is rejected[(a)]
Total Mass	*97
As	*99+
Cd	14
Cr	62
Cu	*99+
Fe	*94
Pb	52
Mn	53
Hg	43
Ni	67
Zn	76
F	14
Cl	26

*Denotes a level of confidence high enough to reject the hypothesis.

(a) Values in table are rounded to nearest integer.

TABLE 38. HYPOTHESIS THAT THE MEANS OF THE FOLLOWING SAMPLE GROUPS ARE IDENTICAL 12-HOUR DAY AND 12-HOUR NIGHT SAMPLES

Element	Level of confidence (%) with which hypothesis is rejected[(a)]
Total Mass	88
As	*95
Cd	37
Cr	31
Cu	43
Fe	29
Pb	34
Mn	69
Hg	70
Ni	67
Zn	79
F	28
Cl	9

*Denotes a level of confidence high enough to reject the hypothesis.

(a) Values given in table are rounded to nearest integer.

First Hypothesis. It was hypothesized that the arithmetic means of the sample concentrations for a particular element (total mass and trace element concentration) obtained at each of the monitoring sites originated from the same hypothetical population and therefore were identical. The results of the analysis of variance performed on this hypothesis are shown in Table 35.

For any high level of confidence, the hypothesis would be rejected. Thus, when applied to the total mass measurements, the hypothesis is rejected because of a 99 percent value. In other words, the concentrations of total mass significantly vary between some or all of the monitoring sites. This is a reasonable finding since the greatest fugitive dust concentrations were observed at the monitoring sites closest to the sources. It is also shown in Table 35 that the hypothesis is rejected as not true for concentrations of arsenic, copper, and iron. Thus, the concentrations of these trace elements vary significantly among some or all of the monitoring sites.

For those trace elements which had a level of confidence less than 90 percent, the hypothesis cannot be statistically rejected. Random variations in the concentration measurements were too large to allow rejection of the hypothesis.

Second Hypothesis. It was also hypothesized that the concentration means for a particular element were identical between the following groups of monitoring sites: Sites 1 and 3, 4 and 5, and 8 and 9. The results shown in Table 36 are consistent with earlier findings. The hypothesis is rejected for the total mass concentrations, arsenic, and iron. Their confidence levels were all greater than 90 percent. It can be inferred from these results that there is a significant variation in arsenic, iron, and total mass concentrations among the groups of monitoring sites specified in the hypothesis.

Third Hypothesis. An analysis of variance was also performed in comparing the 24-hour samples and the 12-hour day and 12-hour night samples. The 24-hour monitoring sites during the three campaigns were Sites 6, 7, 9, and 10. Sites 6 and 7 were generally upwind of the fugitive dust sources during the three monitoring campaigns, while Sites 9 and 10 were located farthest downwind from the sources. The 12-hour day and night samples were obtained from Sites 1, 2, 3, 4, 5, and 8 closest to the sources. It was hypothesized that the means of these three samples groups were identified. Thus, for a particular element, $\overline{u}_1$ (24-hour samples) = $\overline{u}_2$ (12-hour day samples) = $\overline{u}_3$ (12-hour night samples).

As shown in Table 37, the hypothesis is rejected for the total mass particulate concentration with a 97 percent level of confidence. Likewise, as in the first two tests, the hypotheiss is rejected for arsenic, copper, and iron whose confidence levels are greater than 90 percent. The results of the first three analysis of variance tests begin to indicate an interesting conclusion; namely, that in addition to total particulate concentrations, arsenic, copper, and iron concentrations appear to have significant variation with respect to time and distance from the sources.

Fourth Hypothesis. A final hypothesis analyzed was that for a particular element, the mean concentration of the 12-hour day samples is identical to that of the 12-hour night samples. The results are shown in Table 38. Here, the hypothesis is convincingly rejected only for arsenic with a 95 percent confidence level. The hypothesis is not true for total mass concentrations with a confidence level (88 percent) slightly below the criteria percentage of 90 percent.

Campaign I - 8 p.m. December 17 to 8 p.m. December 19, 1976.

December 17, 1976--Friday. Light snow fell throughout the day, accumulating 1 to 2 inches by nightfall. Cloudy skies prevailed throughout most of the night; temperatures were well below freezing throughout the day and night.

December 18, 1976--Saturday. By dawn, skies had cleared and some warming occurred throughout the day. The snow that fell the previous day melted by noon and by midafternoon much of the surface moisture had evaporated. Skies remained clar throughout the day and temperatures rose to about 32 F. Temperatures fell to the mid-twenties during the night. Wind speeds were especially low because of the influences of a high-pressure area situated 100 miles south of the power plant and also because of a nighttime temperature inversion which developed from radiational cooling.

December 19, 1976--Sunday. Warm air advection began before sunrise and continued throughout the day, causing an increase in wind speed and temperature. Skies were mostly sunny. Temperatures rose into the 50's by late afternoon. A good deal of soil drying had occurred during the past two days. The first campaign ended at 8 p.m. Sunday.

Campaign II - 8 p.m. January 5 to 8 p.m. January 7, 1977.

January 5, 1977--Wednesday. Variable cloudiness and cold temperatures were the agenda for the day. About 6 inches of snow covered most of the study area. However, some earlier drifting of snow had left some areas exposed, especially within the grounds of the power plant. Temperatures rose to a tropical 15 F. Skies were partially overcast during the night.

January 6, 1977--Thursday. It continued very cold today and skies became increasingly overcast, with a threat of precipitation appearing in the west horizon by darkness. Temperatures, however, rose to about freezing. Snow began at 7 p.m. and persisted throughout the night.

January 7, 1977--Friday. Snow continued to fall steadily until about 9 a.m. About 5 inches had fallen during the night. A period of snow squalls occurred during the late morning and early afternoon hours. Winds were very strong, gusting to about 40 mph throughout the daylight hours and causing blowing and drifting of snow. Temperatures dropped to 15 F by evening. Campaign II came to an end at 8 p.m.

Campaign III - 8 p.m. April 5 to 8 p.m. April 7, 1977.

April 5, 1977--Tuesday. Rain which fell during the previous two days created saturated soil conditions. Soil evaporation occurred this day, associated with partly cloudy skies through late afternoon. Temperatures were unseasonably cold, reaching only 44 F. Showers began in the late afternoon, and these later changed to snow flurries. Snow flurries and snow squalls continued throughout the night.

April 6, 1977--Wednesday. A snow blanket about 1 inch deep covered the ground during the morning hours. Heavy snow squalls lasting 5 to 30 minutes each and accompanied by strong gusty winds persisted throughout the day. Intervals of sunshine melted any accumulation of snow resulting from the snow squall. Flurries continued into the night.

April 7, 1977--Thursday. Clear skies gave way to cloudy conditions by late morning. Temperatures were slightly above freezing. Showers began around noon and persisted until the early evening hours. Winds continued to be gusty as they had been throughout the monitoring period. Campaign III ended at 8 p.m.

References

A-1. Thomas, T. J., and Ambrose, D. P., Battelle's Fugitive Dust Model, Battelle's Columbus Laboratories (1976).

A-2. Multiple Point Source Model (PTMTP), DBT 51, U.S. Environmental Protection Agency, UNAMAP Tape (PB 229-771), Research Triangle Park, North Carolina (November 29, 1974).

A-3. Vekris, S. L., "Dispersion of Coal Particles from Storage Files", Ontario Hydro Research Quarterly, Second Quarter, 23 (2), (1971).

APPENDIX B

TERRESTRIAL BIOTA OBSERVATIONS

TABLE 39. WOODY SPECIES RECORDED AROUND THE HOMER CITY POWER COMPLEX

Common Name	Scientific Name
Alder	*Alnus* sp.
Apple	*Malus* sp.
Ash, green	*Fraxinus pennsylvanica*
Ash, white	*Fraxinus americana*
Aspen, big tooth	*Populus grandidentata*
Basswood, American	*Tilia americana*
Beech, American	*Fagus grandifolia*
Blackgum	*Nyssa sylvatica*
Boxelder	*Acer negundo*
Crabapple	*Malus* sp.
Cherry, wild black	*Prunus serotina*
Devil's walkingstick	*Aralia spinosa*
Dogwood, flowering	*Cornus florida*
Dogwood, round leaf	*Cornus drummondii*
Fir, balsam	*Abies balsamea*
Hawthorn	*Crataegus* spp.
Hemlock, eastern	*Tsuga canadensis*
Hickory, shagbark	*Carya ovata*
Hickory, shellbark	*Carya laciniosa*
Hornbeam, American	*Carpinus caroliniana*
Larch, subalpine	*Larix lyalli*
Locust, black	*Robinia pseudoacacia*
Maple, red	*Acer rubrum*
Oak, black	*Quercus velutina*
Oak, blackjack	*Quercus marilandica*
Oak, chestnut	*Quercus prinus*
Oak, chinkapin	*Quercus muehlenbergii*
Oak, northern red	*Quercus rubra*
Oak, pin	*Quercus palustris*
Oak, scarlet	*Quercus coccinea*
Oak, shingle	*Quercus imbricaria*
Oak, shumard	*Quercus shumardii*
Oak, white	*Quercus alba*
Pine, red	*Pinus resinosa*
Pine, Scotch	*Pinus sylvestris*
Pine, Virginia	*Pinus virginiana*
Pine, white	*Pinus strobus*
Redcedar, eastern	*Juniperus virginiana*
Sassafras	*Sassafras albidum*
Spicebush	*Lindera benzoin*
Spruce, blue	*Picea pungens*
Spruce, Norway	*Picea abies*
Spruce, red	*Picea rubens*
Sumac, staghorn	*Rhus typhina*
Sycamore	*Platanus occidentalis*
Walnut, black	*Juglans nigra*
Willow, black	*Salix nigra*
Witchhazel	*Hamamelis virginiana*
Yellow-poplar	*Liriodendron tulipifera*

TABLE 40. MEDIUM AND LARGE SIZE MAMMALS RECORDED AROUND THE HOMER CITY POWER COMPLEX[a]

Common Name	Scientific Name	Estimated Abundance
Virginia Oppossum	Didelphis virginiana	Common
Eastern Cottontail	Sylvilagus floridanus	Common
Gray Squirrel	Sciurus carolinensis	Common
Muskrat	Ondatra zibethicus	Rare
Raccoon	Procyon lotor	Abundant
White-tailed Deer	Odocoileus virginianus	Abundant
Woodchuck	Marmota monax	Common

(a) Records include mammals observed and/or their sign noted. Mammal sign involves tracks, droppings, nests, burrows, etc. Observations were made on December 15-16, 1976 and April 11-15, 1977.

TABLE 41. BIRDS OBSERVED AROUND THE HOMER CITY POWER COMPLEX(a)

		Observed at	
Common Name	Scientific Name	Ash Disposal Area	Refuse Disposal Area
Cooper's Hawk	*Accipiter cooperii*		Present
Red-tailed Hawk	*Buteo jamaicensis*		Present
American Kestrel	*Falco sparverius*	Present	
Downy Woodpecker	*Dendrocopos pubescens*	Present	Present
Blue Jay	*Cyanocitta cristata*	Present	Present
Common Crow	*Corvus brachyrhynchos*	Present	Present
Black-capped Chickadee	*Parus atricapillus*	Abundant	Abundant
Tufted Titmouse	*Parus bicolor*	Abundant	Present
White-breasted Nuthatch	*Sitta carolinensis*	Abundant	
Brown Creeper	*Certhia familiaris*	Present	
Carolina Wren	*Thryothorus ludovicianus*	Present	
American Robin	*Turdus migratorius*		Present
Golden-crowned Kinglet	*Regulus satrapa*	Present	
Cardinal	*Cardinalis cardinalis*	Present	Abundant
American Goldfinch	*Spinus tristis*	Present	Abundant
Tree Sparrow	*Spizella arborea*	Abundant	
Field Sparrow	*Spizella pusilla*	Present	Present
White-throated Sparrow	*Zonotrichia albicollis*		Present

(a) Observations made during 5 hours on the afternoons of December 15 and 16, 1976.

TABLE 42. REPTILES AND AMPHIBIANS OBSERVED AROUND PONDS AND STREAMS NEAR THE HOMER CITY POWER COMPLEX[a]

Common Name	Scientific Name
	Reptiles
Queen Snake	*Natrix septemvittata*
Wood Turtle	*Clemmys insculpta*
	Amphibians
American Toad	*Bufo americanus*
Green Frog	*Rana clamitans*
Northern Two-lined Salamander	*Eurycea bislineata bislineata*

(a) Observations made during April 11-15, 1977.

APPENDIX C

WATER QUALITY DETERMINATIONS

Land Use Analysis

Because the watersheds at Homer City are influenced by a number of land uses other than the proposed coal preparation plant, a cause-effect matrix was developed based on the expected interactions between the land use class and the water quality. A set of five major land use classes was identified--farming, mining, urban, construction, and power generation. Power generation is further separated into water treatment and associated sludge disposal; wastewater treatment, industrial and domestic; cooling water; blowdown discharge; ash sluice overflow; ash disposal; coal storage; and oil storage. In attempting to trace the fate of pollutants from these activities, the pollutant parameters ideally should be mutually exclusive for each.

The monitoring of water quality in a watershed containing a number of pollution sources should resolve the origin of the pollution. Each source can be monitored, but the downstream impact would remain unknown. The distance from a particular source to the point of discharge to the stream also plays a role in influencing the quantity of material (yield) actually entering the stream from the water shed. Variations of distances from sources having similar chemical characteristics will complicate the task of making accurate predictions. Finally, pollutants are generally nonconservative as they travel from the source to the discharge point. Individual pollutant species may change radically over a distance and interactions between pollutants from different sources may occur to produce a pollutant with another set of chemical and physical attributes. This new species may be more or less toxic, more or less soluble, and so forth, than its precursors.

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Agricultural Activities

The pollutants resulting from agricultural discharges include sediments, nutrients, pesticides, oxygen-consuming organic loads, and pathogens. Pesticides and pathogens were excluded from the water quality monitoring survey because of the low potential for these pollutants to be present in any of the effluent streams from the coal preparation plant. Cropland is responsible for about 50 percent of the total sediment yield in inland waterways. Sediment also carries with it significant quantities of organic and inorganic matter including: plant nutrients, pesticides, pathogens, and other water pollutants.

Pasturelands are also included in this use classification. Cattle and sheep, even though grazing over relatively large areas, may cause sediment increases by breaking down the streambanks while drinking. Additional sediment, organic matter, and nutrients are contributed by run-off water flowing through and around grazing areas, feeding troughs, hayracks, and other areas where a higher than average animal density occurs. Nutrients from cropland and pastureland may be carried by water in both dissolved and particulate forms. Leaching can occur from both commercial fertilizers and animal manure. Commercial fertilizers consumed during 1972 amount to about 37 million metric tons (41 million tons) in the United States. These fertilizers contain roughly 20 percent nitrogen, 5.2 percent phosphorus, and 8.8 percent potassium. Nutrients from animal manure are an especially serious problem when manure is spread on frozen ground during the winter and early spring. Snowmelt and spring rains cause the nutrients to be transported to nearby streams. Some of these nutrients can also be transported to groundwater.

Mining Activities

Mining activities are a potential source of several pollutants. However, the most serious pollutant arising from mining activities is the mine drainage generated by oxidation of pyritic materials with air in the presence of water; this drainage is an acidic mixture of iron salts, other salts, and sulfuric acid. Mine drainage arises from both underground and surface mining sources. Coal deposits are commonly associated with pyrite and marcasite, which are disulfides of iron. Acid mine drainage can find its way into surface waters, where the acid and sulfate may result in severe deterioration in stream quality. The acid can react with clays to yield aluminum concentrations sufficient for fish kills and with limestone to yield very hard waters which are expensive to soften. The acid can also selectively extract heavy metals present in trace quantities in mineral and soil formations, and this ultimately results in toxic conditions in lakes and streams.

Mining refuse--waste materials left near the mining site after raw minerals have been cleaned or concentrated--is another source of pollution. Much of this refuse contains pyritic material which can be oxidized to acidic substances. The resultant acid water may remain in the pile until a rainstorm, at which time it is flushed into nearby watercourses. Mine drainage "slugs" during storms are very detrimental to aquatic life in surface waters.

Many chemical reactions produce acid mine drainage. The most important reactions, however, are those involving the oxidation of pyrite. Mine drainage from pyrite oxidation is generally shown as occurring in three steps: (1) oxidation of pyrite to ferrous sulfate and sulfuric acid; (2) oxidation of ferrous sulfate to ferric sulfate; and (3) hydrolysis of ferric sulfate.

The oxidation of pyrite to ferrous sulfate and sulfuric acid is rapid if the pyrite is exposed to moist air:

$$FeS_{2(s)} + 3\text{-}1/2\ O_2 + H_2O \rightarrow 2SO_4^{-2} + Fe^{+2} + 2H^+ \quad . \qquad (1)$$

Moisture condensation, flooding, and natural drainage processes flush the ferrous sulfate-acid mixtures into watercourses, where dissolved oxygen in the water will slowly oxidize the ferrous iron to ferric iron. This oxidation may be catalyzed by other metals (i.e., manganese, copper, and aluminum) or by bacteria (Ferrobacillus ferroxidans):

$$Fe^{2+} + 1/4\ O_2 + H^+ \rightarrow Fe^{3+} + 1/2\ H_2O \quad . \qquad (2)$$

Finally, as the ferric sulfate is diluted by a receiving stream, it will be hydrolyzed to form colloidal ferric hydroxide (so-called yellowboy) and sulfuric acid.

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3\downarrow + 3H^+ \quad . \qquad (3)$$

Reaction (1) does not represent the only possible reaction between pyrite and an oxidizing agent to yield SO_4^{-2}, H^+, and Fe^{2+}. It has been demonstrated that Fe^{3+} can also be an effective oxidizing agent.(C-6) The kinetics and reaction mechanisms of pyrite oxidation are extremely complicated and are not examined in greater detail here.

It has long been recognized that the above reactions are insufficient to characterize mine drainage. For example, if the drainage passes through a calcareous shale or limestone region, the acid will be neutralized and converted into calcium (or magnesium) sulfate salinity [Reaction (4)]:

$$H_2SO_4 + Ca(Mg)CO_3 \rightarrow Ca(Mg)SO_4 + H_2CO_3 \quad . \qquad (4)$$

Carbonic acid generated by the neutralization of acid mine drainage will continue to dissolve limestone to produce calcium bicarbonate [Reaction (5)], the material which provides the natural alkalinity of practically all surface and subsurface waters:

$$H_2CO_3 + Ca(Mg)CO_3 \rightarrow Ca(Mg)(HCO_3)_2 \quad . \qquad (5)$$

The presence of bicarbonate alkalinity in neutralized mine drainage has important ramifications. Some of this alkalinity may be attributed to ferrous bicarbonate. Ferrous bicarbonate can react with oxygen to form ferric hydroxide and carbon dioxide, thus providing a mechanism for iron oxidation without the formation of sulfuric acid [Reaction (6)]:

$$Fe(HCO_3)_2 + 1/2\ O_2 + H^+ \rightarrow Fe(OH)_3\downarrow + 2CO_2\uparrow \quad . \qquad (6)$$

If mine drainage passes through noncalcareous clays and shales, it may extract aluminum as aluminum sulfate. Aluminum sulfate can hydrolyze to precipitate aluminum hydroxide and liberate sulfuric acid, through reactions analogous to those with ferric iron.

Many clays contain alkali oxides (potassium or sodium oxide) in significant quantities. A representative chemical analysis of a Pennsylvania clay indicates 6.09 percent K_2O and 0.17 percent Na_2O. The presence of alkali oxide in clays provides a neutralization path for acid mine drainage other than reactions with limestone or calcareous shales.

Mine drainage has been categorized into four classes. Data for these classifications are presented in Table 43. Distinctions among the various classes are derived from drainage pH (hence acidity) and from the oxidation state of the dissolved iron.(C-7)

Mining operations also generate wastes, commonly called spoil, in the form of disturbed rock and soil. If this spoil is left in piles, erosion and run-off will carry sediment into streams. This sediment is capable of destroying life in streams, results in decreased capacity of streams and reservoirs, and destroys fish and wildlife habitats.

TABLE 43. MINE DRAINAGE CLASSES

	Class I, Acid Discharges	Class II, Partially Oxidized and/or Neutralized	Class III, Oxidized and Neutralized and/or Alkaline	Class IV, Neutralized and Not Oxidized
pH	2 - 4.5	3.5 - 6.6	6.5 - 8.5	6.5 - 8.5
Acidity, mg/l as $CaCO_3$	1,000 - 15,000	0 - 1,000	0	0
Ferrous iron, mg/l	500 - 10,000	0 - 500	0	50 - 1,000
Ferric iron, mg/l	0	0 - 1,000	0	0
Aluminum, mg/l	0 - 2,000	0 - 20	0	0
Sulfate, mg/l	1,000 - 20,000	500 - 10,000	500 - 10,000	500 - 10,000

Source: Reference C-7.

Construction Activities

Temporary activities are included in this discussion. During the operational phase, the influence of construction activities on the measured water quality will be minor.

The two major categories of pollutants associated with construction are sediments and, to a lesser extent, chemicals. Sediment consists of deposited particulates which have been transported by rainfall runoff and the wind. Particulates carried by the wind are usually deposited in places where the wind motion is obstructed by trees, grass, and buildings, i.e., where the wind energy of motion vanishes. Particulates picked up by rain runoff from construction sites are deposited downstream in receiving water bodies such as ponds, reservoirs, and dams. Sediment deposition occurs when the sediment load requires more energy to carry than the runoff can furnish.

Sediment has physical, chemical, and biological effects on the receiving stream and water bodies. Sediment deposition can cause physical damage. For example, it can reduce water storage capacity; fill harbors and navigation channels; cause more frequent flooding, resulting in increased bank erosion; increase the suspended solids content (turbidity), thus reducing light penetration; damage fish eggs and gills; destroy and cover organisms on the beds of streams; reduce the flowing speed and the capacity of streams; destroy and impair drainage ditches, culverts, and bridges; alter the shape and direction of stream channels; destroy water recreational areas; and impart an undesirable taste to drinking water.

In addition, sediment deposition leads to an increase in the cost of water treatment as well as in the cost of maintenance through the requirement for frequent dredging.

Chemical pollutants are generated from various operations and materials used throughout various construction activities. Chemical pollutants originate from inorganic and organic sources. These sources may be in solid form in such construction materials as boards and fibers and in liquid form as in paints, oils, and glues. Organic materials have been gaining wider use in the manufacture of construction materials.

Synthetic and nonsynthetic organic liquid chemicals are widely used for surface treatment of walls, for sealing cracks in roofs and floors, for gluing materials together, and in liquid and spray paints. Fuels are used as energy sources in construction activities. They include oils, gasoline, and diesel fuel as used in trucks, power generators, backhoes, bulldozers, and other construction equipment. Other organic materials used in construction activities include fertilizers, pesticides, plastics, rubbers, and curing agents.

Construction operations at Homer City are capable of generating many types of water pollutants. The amount and type of pollutants generated during construction will depend upon the type and time duration of the various construction practices; the location and size of the construction site; the rainfall distribution and frequency; pest control measures; the resistance of the soil or land surface to erosion by gravity, water, and wind; the chemical properties and geology of subsurface soils; and the number of people and machines linked with each construction site.

Construction practices typical of a given site will involve the following: clearing, grubbing, and pest control, rough grading, facility construction, and the restoration of staging and stockpile areas on completion of the job. These practices constitute the prime source of various types of water pollutants resulting from construction.

Petroleum products are the largest group of materials consumed in construction activities. Petroleum products consist of oils, grease, fuels, certain solvents, and many others. Pollutants from construction activities may include crank case oil wastes, oil leakage from storage containers, oil solvents, dust control oils, minor oil spills during transfers and transportation, oil-laden rags, and degreasers.

A majority of these materials float over the surface of the water and spread easily over a wide area. Oils and other petroleum products are readily absorbed by sediment, which is the main carrier of these materials. Sediment contaminated with oil is carried in runoff to receiving streams. The inherent properties of petroleum products make them extremely difficult to control after they enter water bodies.

The extent of water pollution caused by petroleum products at construction sites is dependent on the occurrence of spills from storage tanks, the quantity of crank case oil wastes disposed of, the number of trucks and construction equipment operated as well as the state of their maintenance, and the magnitude of the construction activity.

Some petroleum products impart a persistent odor and taste to water and to fish flesh. Many oils have the ability to block the transfer of air from the atmosphere into water, which results in the suffocation of aquatic plants, organisms, and fish. Some petroleum products contain quantities of organometalic compounds (nickle, vanadium, lead, iron, arsenic) and other organic components which can be toxic to fish and other organisms.

Urban Activities

Runoff and domestic sewage effluent are the two major causes of urban water quality degradation.

Urban runoff is largely the result of storm water striking impervious rooftops, driveways, and streets and flowing into gutters. During its passage across surfaces loaded with atmospheric fallout or automobile emissions, the runoff picks up and transports a variety of pollutants into the storm sewer system. Frequently, sewage treatment plants are not sized to treat the extremely large volumes of water represented by urban runoff so that storm sewers are designed to discharge directly into streams and rivers.

The most significant pollutant in terms of quantity is sediment. During periods between rains, large amounts of solids from lawns, vehicles, atmospheric fallout, and other sources can accumulate on hard surfaces. A subsequent rainstorm will wash off a large fraction of these pollutants in the early stages of the storm. Since the rate of wash-off is roughly exponential and because the peak in the amount of water lags the movement of solids, a large slug of highly polluted water is introduced to the receiving water in the initial stages of runoff. This is the so-called "first flush" phenomenon.

In addition to suspended solids, urban runoff contains varying quantities of other pollutants such as organic materials (oxygen demand), nutrients, and heavy metals. Chlorides from street salting are also washed into receiving waters during winter and spring snowmelt.

The second component of urban pollution, domestic sewage, is of concern primarily for its relatively continuous inputs of organic materials. Most wastewater plants afford adequate treatment and considerable amounts of dilution to a waste so that lack of dissolved oxygen is generally not a problem; however, during rainy periods infiltration and hydraulic overloading may occur, resulting in poor plant efficiency. Some small communities in the study area do not treat their wastes before discharging to the receiving waters.

Domestic wastewater treatment plants are generally not designed for removal of nitrogen and phosphorus and these, too, may be distributed to a receiving water body along with the organic material. This land use constitutes only a minor portion of the area in any of the watersheds.

Power Generation Activities

The power generation land use category is further subdivided into its component waste streams--water treatment effluent, wastewater treatment effluent, cooling tower blowdown, discharge ash sluice water, ash disposal leachate, coal pile runoff, and oil storage leakage.

Make-up water for boilers and cooling towers must be of high purity to prevent scaling or corrosion problems. Water treatment generally consists of lime-soda softening followed by an ion exchanger train treatment or reverse osmosis. Lime-soda softening removes hardness by precipitating calcium as $CaCO_3$ and magnesium as $Mg(OH)_2$. Solubility considerations suggest that other cations such as Fe^{2+} and Mn^{2+} may also be removed as hydroxides or oxides. To speed precipitation, lime and soda ash are sometimes added in greater than stoichiometric quantities. To aid in settling and dewatering, coagulants such as alum, activated silica, or polyelectrolytes may be added. The resulting sludge is, in some instances, dried and calcined to recover lime and reduce the volume of sludge wasted. In most cases, however, the sludge is dewatered and landfilled. At Homer City, this sludge is transported to the ash-settling ponds for dewatering. It is then removed to the ash disposal area.

To produce the extremely high quality water such as that needed for supercritical steam cycle boilers, nearly all of the ionic constituents must be removed to yield an essentially deionized finished water.

Boiler water condensate is also polished via ion exchange after a number of steam cycles. After a certain period, the exchange sites on the resin become saturated and must be regenerated. At Homer City Station, the cationic and anionic exchangers are regenerated with sulfuric acid and sodium hydroxide, respectively. Regeneration of the demineralizers is a constant activity at the station. The spent solutions, primarily sulfate salts and unreacted regenerants, are piped to the industrial wastewater treatment plant for neutralization and lime precipitation.(C-8)

Wastewater treatment at the Homer City power plant consists of industrial waste treatment and sanitary waste treatment. Industrial wastes include demineralizer and softener regenerants, clarifier filter backwash, ash settling pond filter-bed underflow, coal pile and yard runoff, and miscellaneous station operating wastes. The industrial waste treatment plant is designed to remove both dissolved and suspended pollutants. Suspended solids are removed by a grit chamber. The wastewater is then dosed with a lime slurry and settled in a sedimentation tank. The sludge is trucked to the ash disposal area. Provision is also made for the skimming and removal of oil and grease. Design capabilities of this system are <7 ppm total iron and <200 ppm suspended solids.(C-9) However, because of increasing hydraulic loads, the treatment system has not performed as expected and modifications have been and are continuing to be made. Because of these changes, the historical data are not necessarily representative of present conditions.

The Water Management Task Force report of Fall, 1976, recommended the expansion of the system to provide additional capacity and improved design.(C-7) Changes in effluent quality undoubtedly will occur and must be accounted for in future monitoring.

Sewage treatment capabilities for the power plant are provided by two package systems rated at a total capacity of 19,000 gpd. Each unit consists of an aeration activated sludge tank and a clarifier. The units are designed to achieve an 85 percent reduction in BOD.(C-9) The sanitary effluent is chlorinated to 1 to 2 ppm residual before discharge. Both units are apparently operating at or near their design capabilities.(C-8) A separate 15,000-gpd sewage treatment plant has been installed to handle the wastes from the construction offices for Unit 3.

The cooling water used in the wet draft type towers at Homer City still contains enough impurities after treatment to cause a potential problem with scale formation, if left in the system for an excessive number of cooling cycles. Discharges of water from the towers occur because of the need to dilute these salts in the recirculating cooling water or because of plant shutdown. A portion of the blowdown water is returned to the system for ash sluicing and the excess is discharged. Water entering the cooling towers has been pretreated to remove iron and turbidity and to adjust the pH. A sedimentation stage is also provided. Even so, the blowdown water still contains sufficient suspended and dissolved solids to affect the quality of the receiving body.

The cooling water blowdown is also considerably warmer than the ambient receiving water temperature.

Ash sluicing is a major water-demanding activity at Homer City Station. Bottom ash is sluiced directly from the boiler to the ash hydrobins. The pyrites removal system sluices the rejects from the pyrites hopper to a holding bin and finally to the ash hydrobins. Economizer ash is continuously drained into water-filled storage tanks from which it is periodically removed to the ash hydrobins. Thus, the hydrobins serve as temporary storage sites for all three heavy waste fractions. The stored ash and pyrite are then trucked from the hydrobins to the ash disposal area. The fly ash is collected from the precipitators and transported by conveyor into one of two storage silos. From these, the fly ash is loaded into trucks and taken to the ash disposal area.

The sluice water supernatant from the hydrobins is discharged to a pair of settling ponds where solids are removed. Extensive changes to this system have been made; hence, many of the old data are unusable. Since 1974, most of the water for ash handling has been taken from the overflow of the ash settling ponds instead of from cooling tower blowdown. Pond underdrains are used to dewater the sludge during pond cleanout. Water in excess of recycle needs is allowed to overflow to a ravine for discharge.(C-10) Plans are to reduce the overflow volume by diverting the storm drainage and washdown water from the ash pile and hydrobin areas to a separate treatment facility.

Ash is disposed of on station property about 1/2 mile west of the generating plant. The valley fill method is used for impoundment of the ash, and an earthen embankment downgradient contains the material. Underdrainage is controlled by the use of a French drain collector system which discharges to catch basins below the retention embankment. Layering of bottom ash, fly ash, and pyrites is practiced to control subsidence and prevent channelling. Surface flows are controlled by grading and covering the ash with soil. Grass is then planted to prevent erosion.

In the catch basins, soda ash is added to raise the pH to a point where dissolved iron and other heavy metals will precipitate. The water then flows to a series of settling ponds where the solids are allowed to settle.

A large (500,000 tons) supply of coal is stockpiled at the station to maintain generating capacity in the event of a mine shutdown. Because this coal is not protected or enclosed in any way, runoff and leachate are produced whenever precipitation falls on the pile. The runoff has the same characteristics as acid mine drainage owing to the pyrite in the coal and, in addition, carries fine coal particles. Most of the drainage from the coal pile is impounded in two desilting basins which are equipped with pumps to transfer the impounded runoff to the waste treatment plant for neutralization and solids removal.

Oil is stored at the station to provide fuel for firing the auxiliary boilers. One tank contains 150,000 gallons of No. 2 fuel oil and the other two tanks 200,000 gallons. Other than the obvious contamination potential from the oil itself, trace amounts of phenols may also be present in the oil. In addition, several drainage pits for transformer oil are located in the substation area.

Conclusions

From the above land use analysis, a cause-effect matrix was developed which shows the various existing activities and their potential pollutant characteristics (Table 6). It is not possible to identify unique water quality indicator parameters for each land use because of overlap. Fortunately, not all land uses prevail in each watershed (Table 5). Only Two Lick Creek is affected by the majority of activities.

Analysis of the relationships between the various land uses and water quality should be ultimately extended to include the matrix entries devoted to coal preparation and its interactions with the environment.

Physical Descriptions of the Drainage Basins in the Vicinity of the Homer City Coal Cleaning Plant

General

The principal geologic structure of the entire plant region is the Latrobe Syncline. The trend of its axis is northeast-southwest, and it falls gently about 35 feet per mile toward the southwest. The McKee Run Anticline lies about 4 miles northwest, and the Chestnut Ridge Anticline lies about 3.5 miles southeast. Surface elevations in the study area range from 960 to 1650 feet.

The region is underlain by the Conemaugh formation to an elevation of about 650 feet. The outcropping members are the Connelsville sandstone, which occurs from elevation 1200 to 1260 feet, and the Morgantown sandstone which occurs from 1075 to 1200 feet. These are thin-bedded, fine-grained sandstones interbedded with red and green shales. The sandstones are moderately weathered to 10 to 20 feet deep; the shales are severely weathered to 40 to 50 feet deep.

Beneath the Conemaugh formation is the Allegheny formation. The upper member of the Allegheny is the Upper Freeport coal; the middle members are the Kittanning coals. The Upper Freeport member has been extensively mined throughout the region.

Locally, the underlying strata are characterized by minor synclinal and anticlinal features, all part of the Latrobe Syncline. Bedrock strikes N 25° E and dips a nearly flat 30 feet per mile to the southeast. There are no known faults in the region. Joints are parallel and perpendicular to the axis of the Latrobe Syncline and are generally tightly closed.

Geologic information on the area is available in References C-1 and C-2. Data on precipitation and stream flows are from the NOAA weather station at Blairsville, approximately 8 miles away, and from the USGS gaging station on Two Lick Creek at Graceton, 1 mile southeast of the plant.

Precipitation in the region has averaged 47.58 inches per year. Maximum precipitation was 64.31 inches. Maximum monthly precipitation was 11.13 inches and minimum monthly was 0.39 inch.

Stream discharge for the region which is measured at the USGS gaging station on Two Lick Creek has averaged 21.68 inches per year. (Stream flow rates are converted to areal net discharge by dividing by watershed area.) This includes runoff and groundwater. Groundwater generally flows northeast to southeast. Groundwater levels are usually highest in spring and lowest in early fall.

Most of the groundwater data presented here are for various permit applications prepared by Gilbert & Associates for the Pennsylvania Electric Company and from Reference C-2. Data on soil types and locations come from the USDA Soil Conservation Science Soil Surveys at Indiana County, Pennsylvania.

North Tributary to Cherry Run

The unnamed tributary to Cherry Run north of the refuse disposal area drains an area of approximately 1150 acres. Relief in the drainage basin is about 400 feet (from approximately an elevation of 1000 feet at Cherry Run to a high point of 1388 feet), according to the USGS Indiana, Pennsylvania, quadrangle topographic map, revised in 1973. Maximum slope is about 35 percent, with most of the drainage basin sloping at 10 to 15 percent. The tributary falls fairly gradually at 88 feet per mile.

On the basis of the average discharge in the Two Lick Creek basin above Graceton, 21.68 inches per year, discharge from the north tributary should average 2.8 cfs. However, actual streamflow is known to be intermittent.

The Morgantown and Connelsville sandstones are major water-bearing formations in the area and create numerous springs where they outcrop. The springs occur between elevations of 1050 feet and 1175 feet in the refuse area.

Soils in the area are all silt loams or sandy loams, with erosion potential rated by the Soil Conservation Service as moderate. Thickness of the soil layer is generally 10 to 102 feet.

South Tributary to Cherry Run

The unnamed tributary to Cherry Run north of the refuse disposal area drains an area of approximately 860 acres. Relief in the drainage basin is about 320 feet (from approximately 1000 feet at Cherry Run to a high point of about 1320 feet), according to the USGS topographic map of the Indiana, Pennsylvania, quadrangle. Maximum slope is about 45 percent near the valley bottom in the lower reaches. This occurs over about 5 to 10 percent of the basin. Most of the basin slopes at 10 to 20 percent. The tributary falls at about 100 feet per mile.

On the basis of average discharge of the Two Lick Creek basin above Graceton, 21.68 inches per year, discharge from the south tributary should average 2.1 cfs. However, actual stream flow is known to be intermittent.

The Morgantown and Connelsville sandstones are major water-bearing formations in the area and create numerous springs where they outcrop. The springs occur between an elevation of 1050 feet and 1175 feet in the refuse area. The springs are estimated by the designer of the refuse disposal facility to flow at a maximum of 5 gpm. The total contribution of the springs to stream flow is estimated at not more than 100 gpm.(C-2)

Soils in this basin are all silt loams or sandy loams, with erosion potential rated by the Soil Conservation Service as moderate, except for occasional pockets of a shaley silt loam with severe erosion potential. Thickness of the soil layers is generally 10 to 102 feet.

Cherry Run

Cherry Run drains an area of approximately 11,000 acres, including the tributaries immediately north and south of the refuse area. Relief in the drainage basin is about 670 feet (from approximately 980 at Two Lick Creek to a high point of 1650 feet), according to the USGS topographic map of the Indiana, Pennsylvania, quadrangle revised in 1973. Maximum slope is about 50 percent and occurs at a constriction in the valley now used as a small reservoir about 2-1/2 miles upstream from Two Lick Creek. Most of the basin slopes at 10 to 20 percent. Cherry Run falls at about 20 feet per mile just upstream of the reservoir. Downstream it falls at about 10 feet per mile.

On the basis of average discharge of the Two Lick Creek basin above Graceton, 21.68 inches per year, discharge from Cherry Run should average 28 cfs.

Soils in this basin are silt loams, shaley silt loams, channery silt loams, and channery sandy loams. All are rated by the Soil Conservation Service as having moderate erosion potential, except for occasional isolated pockets of a shaley silt loam with severe erosion potential. Thickness of the soil layer ranges from 5 to 120 feet.

Common Ravine

The Common Ravine drains an area of approximately 230 acres. Relief in the basin is about 240 feet (from approximately 970 feet at Two Lick Creek to a high point of about 1210 feet), according to the USGS topographic map of the Indiana, Pennsylvania, quadrangle. Maximum slope is about 30 percent. Most of the basin slopes at 15 to 20 percent. The stream falls at 200 feet per mile.

On the basis of average discharge of the Two Lick Creek basin above Graceton, 21.68 inches per year, natural discharge from the Common Ravine should be about 0.6 cfs. However, several of the generating station facilities discharge into the Common Ravine. These discharge points and their volumes are:

(1) Two sanitary sewage treatment plants - 17,000 gpd capacity total

(2) Industrial waste treatment plant - 1000 gpm capacity

(3) Surface drainage for the generating station.

If all treatment plants operated at capacity, the additional flow in the Common Ravine would be 2.2 cfs.

Soils in this basin are all silt loams or sandy loams, with erosion potential rated by the Soil Conservation Service as moderate. Maximum thickness of the soil layer is unreported. Bedrock is exposed in this basin.

Second Ravine

The Second Ravine drains an area of approximately 460 acres. Relief in this basin is 280 feet (from approximately 970 feet at Two Lick Creek to a high point of 1254 feet), according to the USGS topographic map of the Indiana, Pennsylvania, quadrangle. Maximum slope is 30 percent; most of the basin slopes at 10 to 15 percent. The upper reaches of the basin have been extensively modified by construction of portions of the generating plant and settling ponds. Slopes in the upper reaches are 10 percent or less. The stream falls at 140 feet per mile. A small impoundment known as Rager's Pond lies about 1000 feet upstream from the confluence of the Second Ravine with the Common Ravine.

The natural discharge of the Second Ravine, based on the average discharge of the Two Lick Creek basin above Graceton, 21.68 inches, should average 1.2 cfs. However, discharges from several settling basins will add an average of 2.6 cfs.

Soils in this drainage basin are silt loams and sandy loams with moderate erosion potential, according to the Soil Conservation Service. Minimum thickness of soil cover is 12 inches, and maximum thickness is 3 feet or more.

Groundwater levels have been reported only for the upper reaches of the basin in the vicinity of the settling ponds. These levels range from a minimum depth to groundwater of 2.9 feet to a maximum depth of 16.0 feet. However, these depths are expected to be highly seasonally variable.

Wier's Run

Wier's Run drains an area of approximately 2250 acres. Relief in the drainage basin is about 440 feet (from approximately 960 feet at Two Lick Creek to a high point of 1402 feet). Maximum slope is 25 percent. Most of the basin slopes at 10 to 20 percent.

An ash disposal facility has been constructed in a small valley off the main channel of Wier's Run. Above the point of entry of drainage from the ash disposal area, Wier's Run falls at 240 feet per mile. Below that point, it falls at about 50 feet per mile.

On the basis of average discharge of the Two Lick Creek basin above Graceton, 21.68 inches per year, discharge from Wier's Run will be about 5.6 cfs. The ash disposal area is not considered to be large enough that its relatively higher infiltration rate and lower evapotranspiration rate will significantly affect the average stream flow. There are no significant water discharges into the ash disposal area.

Groundwater has been reported at the 0- to 6.8-foot depth in the basin. Soil thickness is not known for the entire basin but was reported as greater than 108 inches near the ash disposal area. Soil types are all silt loams rated as having moderate erosion potential.

The Morgantown and Connelsville sandstones are major water-bearing formations in this basin and occasionally create springs where they outcrop. Flow of these springs has not been measured.

Water Chemistry

This section includes a discussion of some equilibrium water chemistry concepts related to the interpretation of data obtained at Homer City. Most water quality constituents behave nonconservatively, i.e., simple dilution models are inadequate to predict the observed distribution of soluble species. Although some parameters are not amenable to interpretation via an equilibrium approach, this technique is still useful not only as a starting point in understanding the existing chemical controls but also in predicting responses of a stream to changes in land use and topography.

For this analysis, the following assumptions have been made:

- The major solubility controls on ferric iron are the amorphous hydroxide and the aquo-hydrolysis products.
- The solubility of calcium and the levels of dissolved carbonate and sulfate are controlled by their solubility products and alkalinity relationships.
- Iron and manganese oxides may be important factors in determining the behavior of trace metals.
- Trace metals are controlled by the solubility of the hydroxide, oxide, or carbonate, and/or by adsorption equilibria.
- Competition between cations for available ligands is of limited importance.
- Activity effects are not considered.
- Fluoride and phosphate anions exert a negligible influence on the system composition.
- The effects of organic chelates are not included.

These assumptions and the lack of precision in some of the equilibrium constants mean that the resulting numerical solutions are a first approximation to an exact and rigorous treatment.

Aqueous Iron Chemistry

Iron may exist in solution in either the bivalent or trivalent oxidation state. Bivalent or ferrous iron solubility is controlled at low pH values by the solubility product of ferrous carbonate, $FeCO_3(s)$, provided alkalinity is greater than 10^{-4} moles per liter. The solubility product of $FeCO_3$ is about 200 times smaller than the solubility product of $CaCO_3(s)$. Ferrous iron concentrations in a water saturated with $CaCO_3$ are, therefore, much lower than its soluble calcium content.

In waters lacking carbonate ion activity and not containing reduced sulfur species (H_2S, HS^-, $S^=$), the solubility of ferrous iron is controlled by the precipitation of ferrous hydroxide, $Fe(OH)_2(s)$. However, the solubility product expression alone is insufficient to determine the maximum soluble ferrous iron concentration. Reactions between the solid phase $Fe(OH)_2$ and the soluble hydroxo complexes must also be included. The distribution of ferrous iron as a function of pH with and without significant concentrations of alkalinity present is shown in Figures 29 and 30.

In the presence of dissolved oxygen, ferrous iron is thermodynamically unstable and is converted to the trivalent oxidation state (Figure 31). The rate of oxidation of ferrous iron is a function of the pH and dissolved oxygen (D.O.) concentration. At low pH and small D.O. values, considerable amounts of ferrous iron may persist in solution because of the sluggish kinetics. Ferric iron solubility is controlled by the amorphous oxide ($Fe(OH_3)$) and hydrous oxide ($FeOOH_2$).

The soluble hydroxo complexes of ferric iron must be included in the solubility expression to obtain valid concentrations of soluble iron. The distribution of ferric iron species with pH is shown in Figure 32. Ferric iron also forms strong phosphate complexes which influence the solubility at phosphorus concentrations exceeding 10^{-4} $\underline{M}$.(C-19) A complicating factor in examining the agreement of predicted and measured solubilities and ferric/ferrous iron ratios is the stabilization of iron in solution by naturally occurring humic or fulvic acids and/or the formation of hydrosols. These stabilized iron colloids may have particle diameters on the order of 0.01 μm which will easily pass the 0.45 μm pores of the Millipore filter used to operationally separate the dissolved and particulate fractions.(C-19)

The concentration of soluble ferrous iron in equilibrium with ferric iron may be determined from the standard half-cell potential for this half-cell and the Nernst Equation:

$$Eh = E_o + \frac{2.3\ RT}{nF} \log \left\{[Fe^{3+}]/[Fe^{2+}]\right\}$$

Soluble ferrous iron can react with hydroxyl ion and be oxidized according to the following reaction: $Fe^{2+} + 3OH^- \rightarrow Fe(OH)_3\downarrow + e^-$.

Substituting the standard potential E_o and the concentration of ferric iron as a function ferrous iron and hydroxyl ion concentration in the Nernst Equation yields:

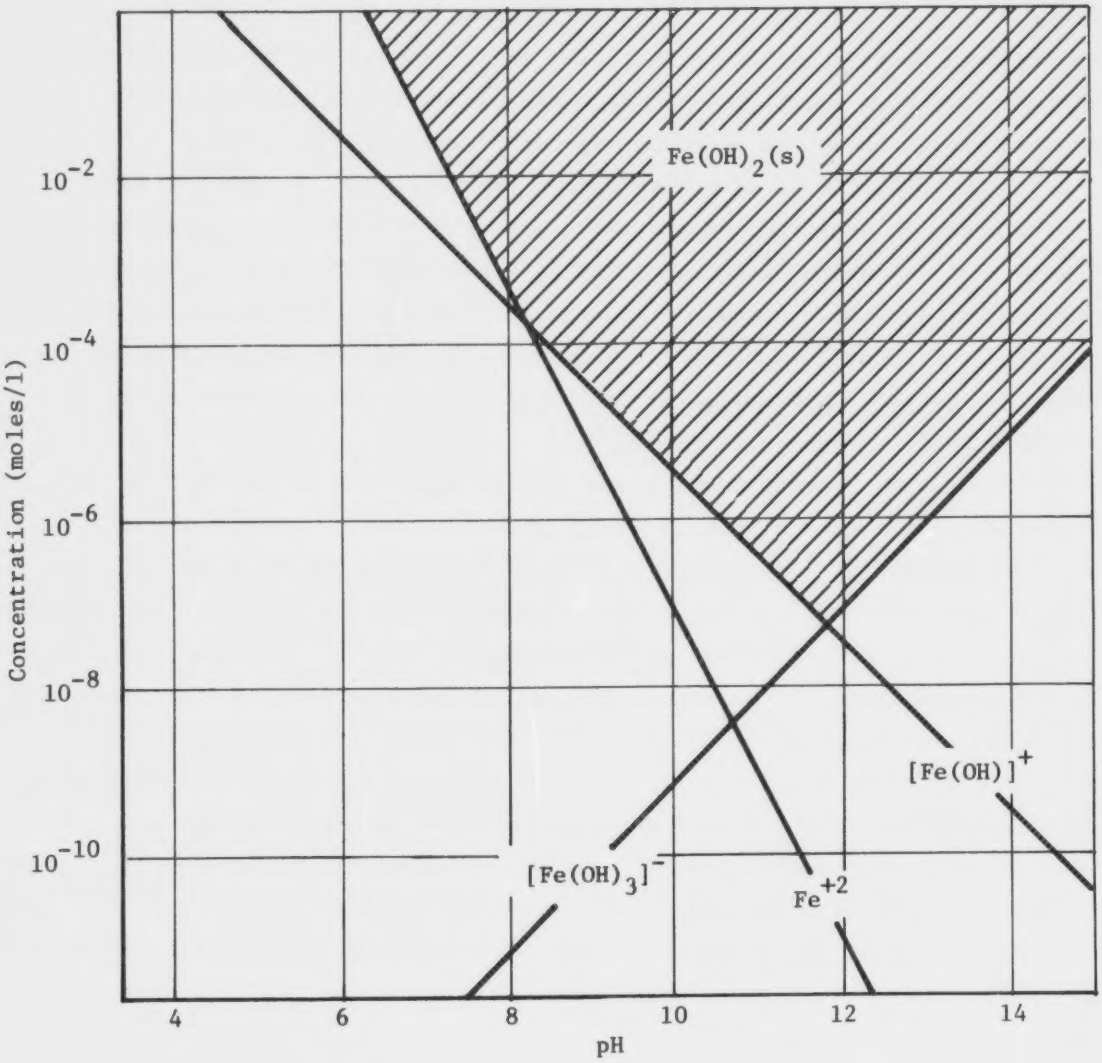

FIGURE 29. CONCENTRATION OF FERROUS IRON AS A FUNCTION OF pH IN A CARBONATE-FREE SYSTEM

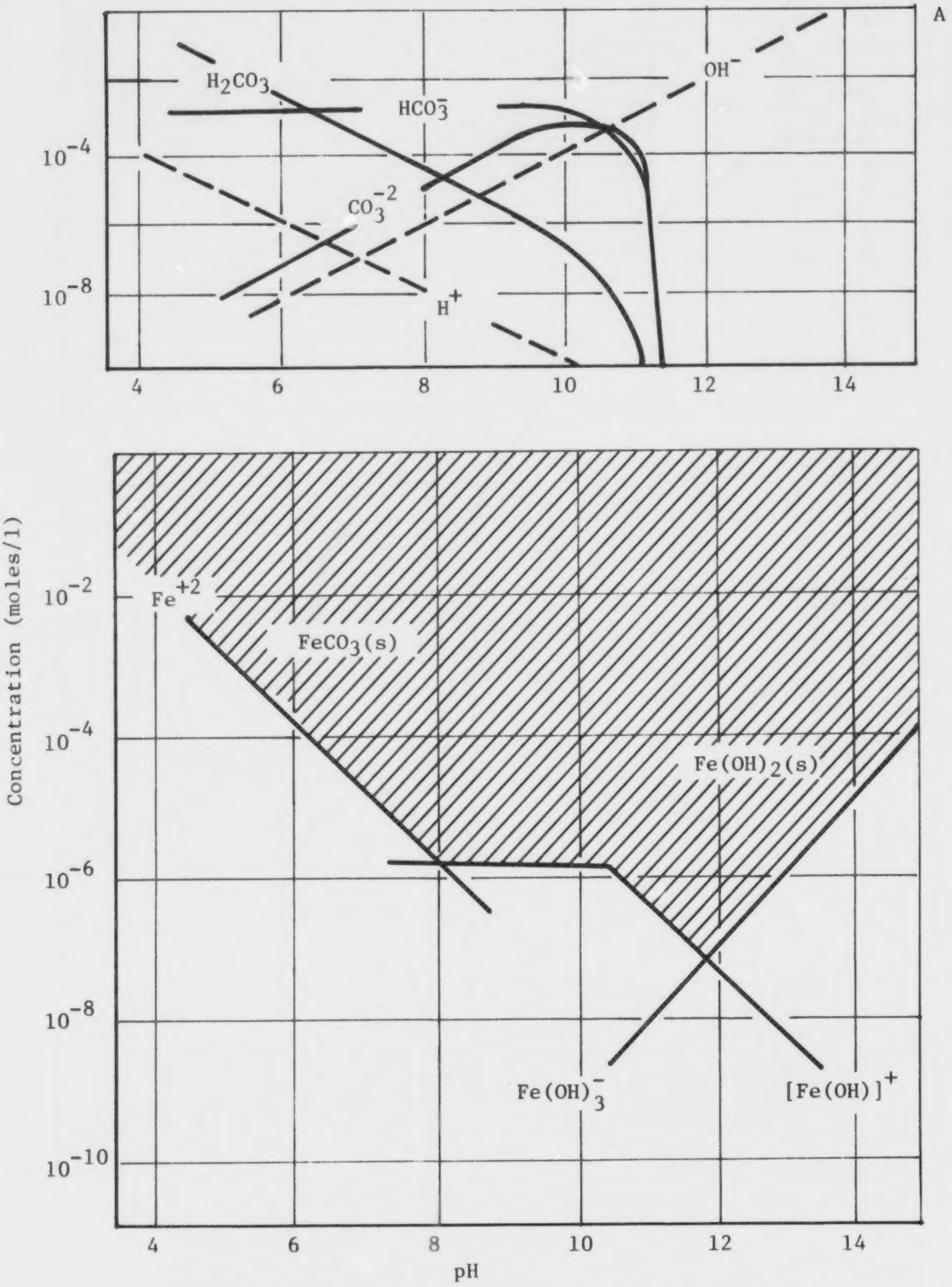

FIGURE 30. SOLUBILITY OF FERROUS IRON AS A FUNCTION OF pH IN A SYSTEM CONTAINING DISSOLVED CARBONATE SPECIES

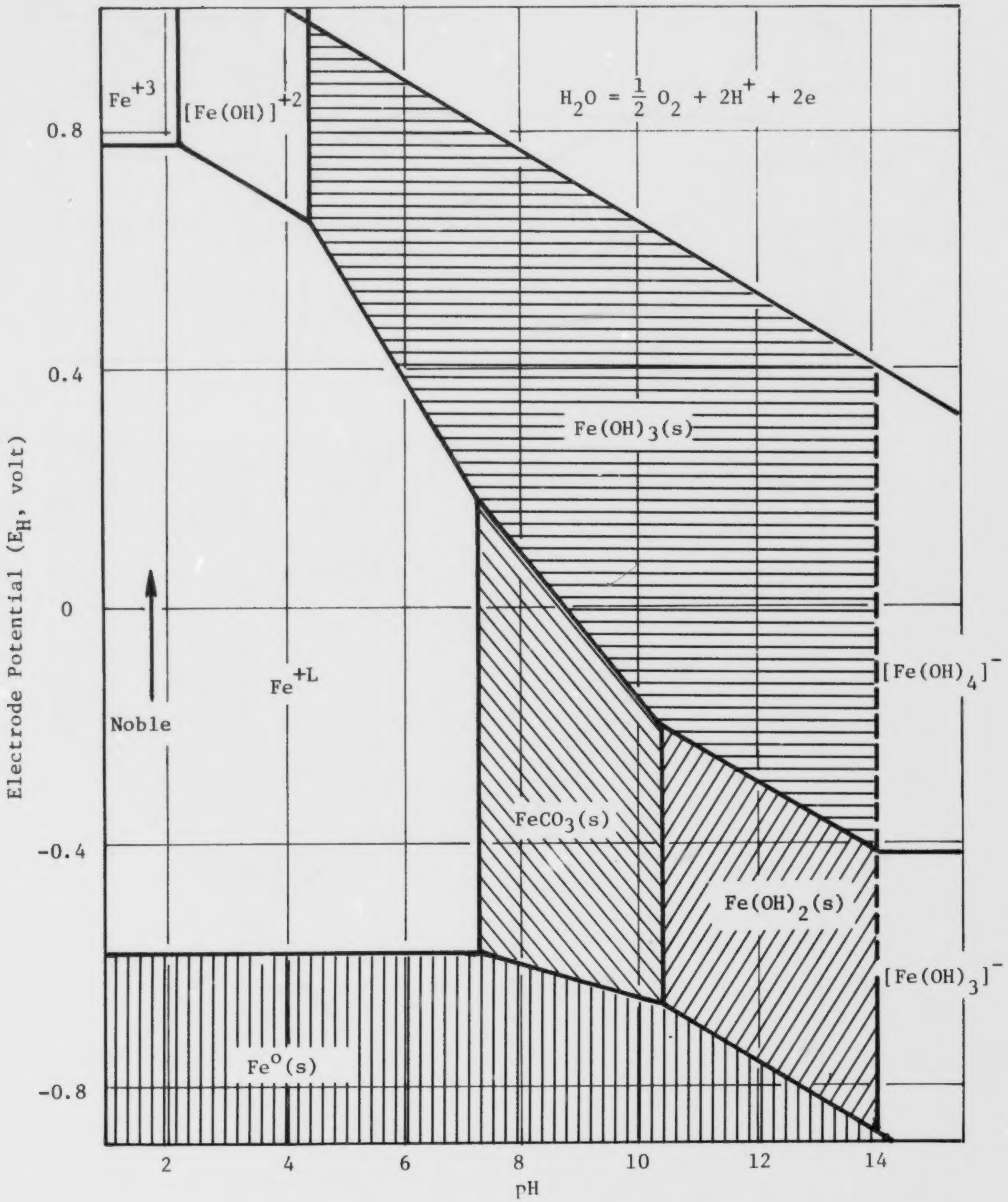

FIGURE 31. STABILITY RELATIONSHIPS IN THE SYSTEM--Fe-O_2-CO_2

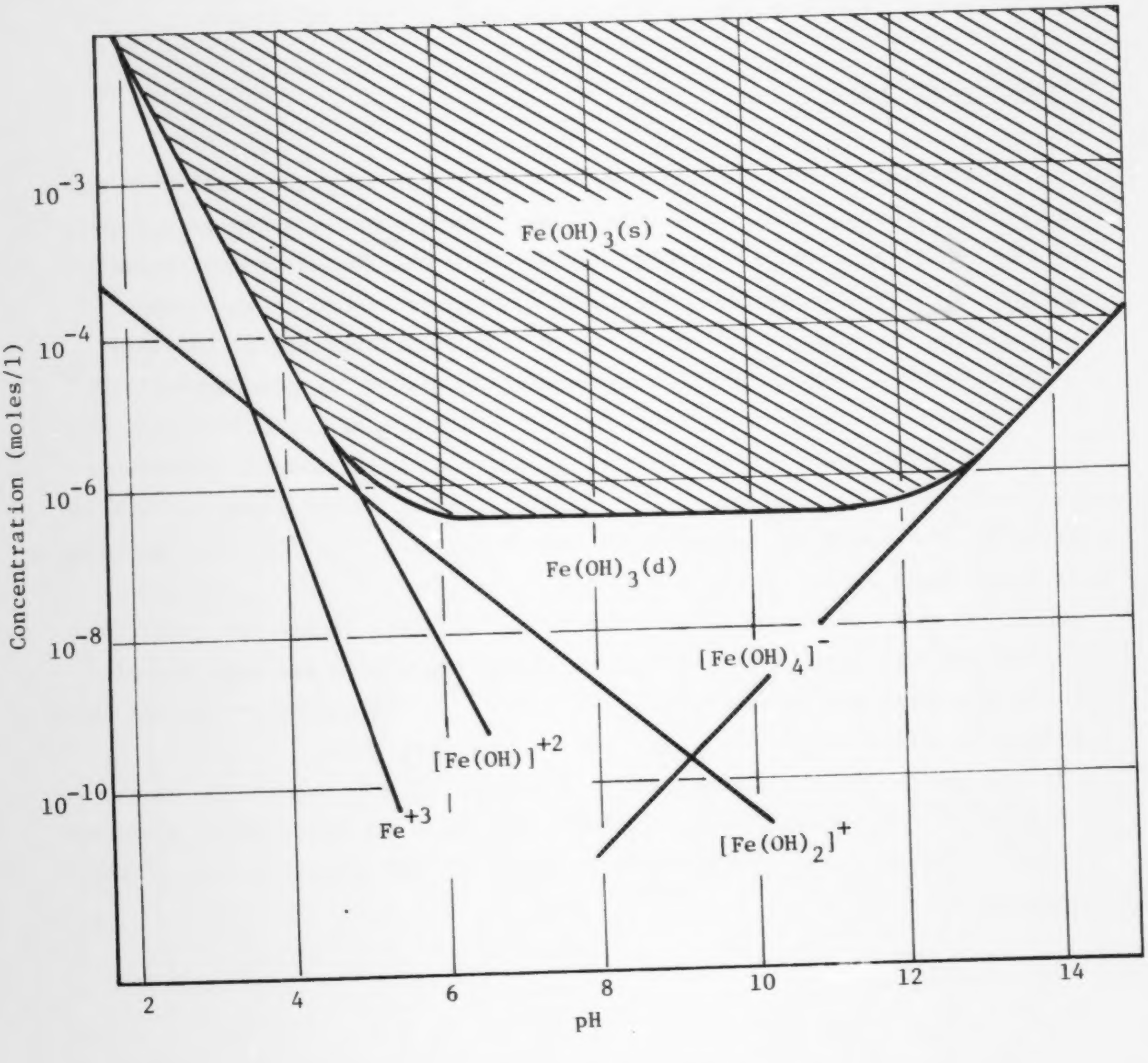

FIGURE 32. CONCENTRATION OF FERRIC IRON AS A FUNCTION OF pH

$$Eh = -1.31V. + 0.059\ \overset{\uparrow\uparrow}{\log}\ \frac{1}{[Fe^{2+}][OH^-]^3} \quad .$$

Figure 33 is a plot of ferrous iron concentration versus pH, assuming an upper and lower bound for the Eh of oxygenated waters of 0.7 and 0.5 volts, respectively, when measured against a standard calomel electrode.

Manganese Chemistry

The behavior of manganese in natural waters is somewhat similar to the behavior of ferrous iron. The solubility of manganese in water is controlled by the solid phases $MnCO_3$ or MnO_2, depending on the Eh and concentration of dissolved carbonate species. The Eh-pH diagram in Figure 34 has been constructed for a total concentration of dissolved carbonate of 100 mg/1 as bicarbonate. Near a pH of 7, manganese in solution is predominantly Mn^{2+} ion; however, in water containing very high bicarbonate concentrations, the manganese bicarbonate complex cation, $MnHCO_3^+$, can significantly contribute to the dissolved Mn species.(C-20) In addition, manganese tends to form ion pairs of the form $MnSO_4^0$ in solutions containing more than 1000 mg/1 of sulfate ion, and these influence the solubility of manganese.(C-20) It should be noted that the relationships depicted in the previous figure are valid only for equilibrium conditions and that manganese equilibria are established relatively more slowly than iron equilibria(C-3). Therefore, manganese tends to stay in solution further from a source than iron does.

Manganese concentrations between 1.0 and 10.0 mg/1 are stable under Eh conditions of oxygenated water. Soluble manganese precipitates as anhydrous oxide, which can exert considerable influence on the concentrations of toxic trace metals.(C-1)

Other Heavy Metals

Control of divalent transition metal ion solubility by the carbonate or hydroxide and hydroxo solids and soluble hydroxo complexes is not limited to ferrous iron. The maximum concentrations of copper, zinc, lead, and nickel that can exist in solution are similarly determined by the solubility of their respective complexes. The solubility relationships of these trace metals as a function of pH are shown in Figure 35. Solubility products and formation constants were obtained from the literature.(C-19,C-20)

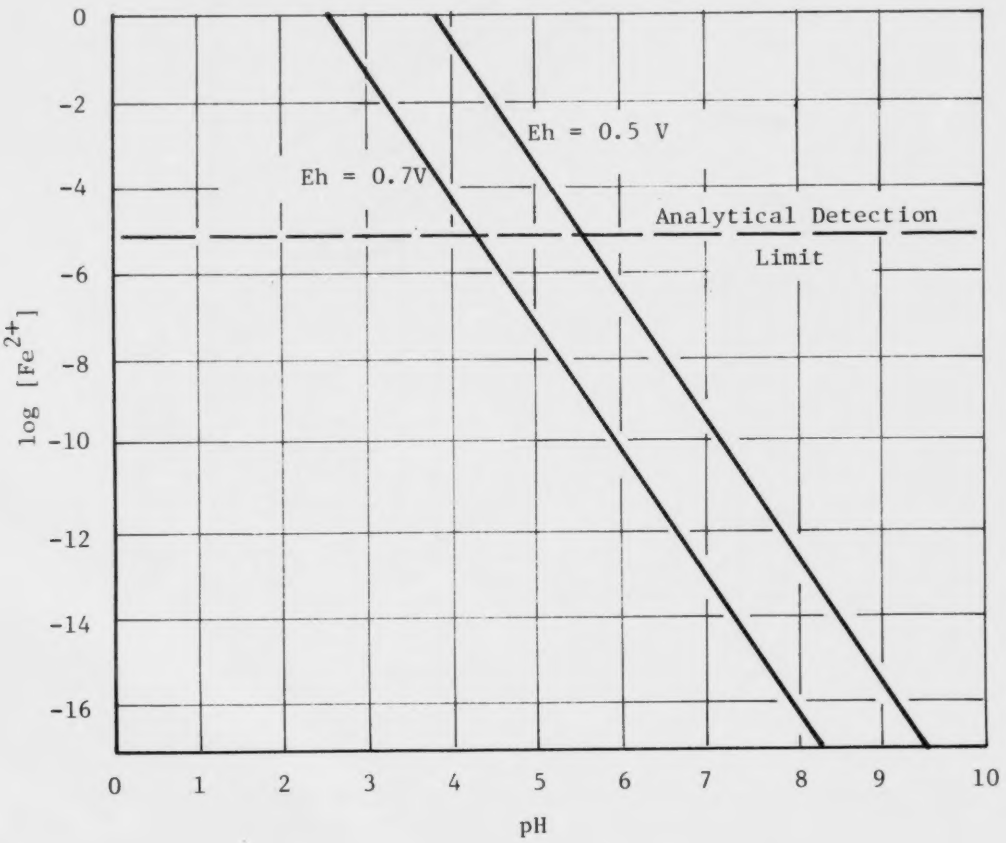

FIGURE 33. SOLUBILITY OF FERROUS IRON IN AN OXYGENATED SYSTEM

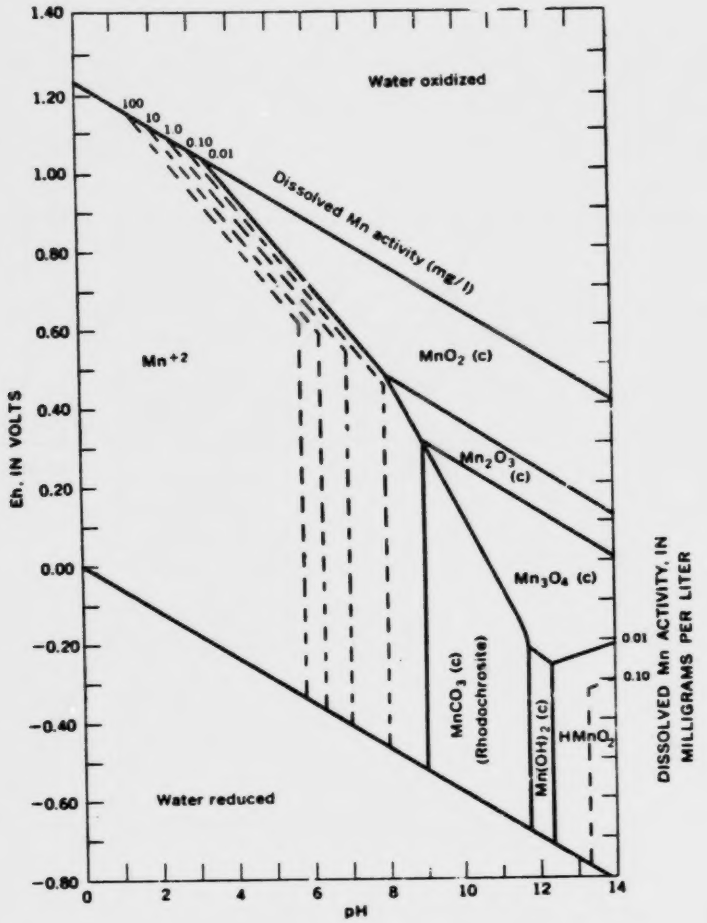

FIGURE 34. FIELDS OF STABILITY OF SOLIDS AND SOLUBILITY OF MANGANESE AS A FUNCTION OF Eh AND pH AT 25 C AND 1 ATMOSPHERE OF PRESSURE

Note: Activity of dissolved carbon dioxide species 100 mg/l as HCO_3^-. Sulfur species absent.

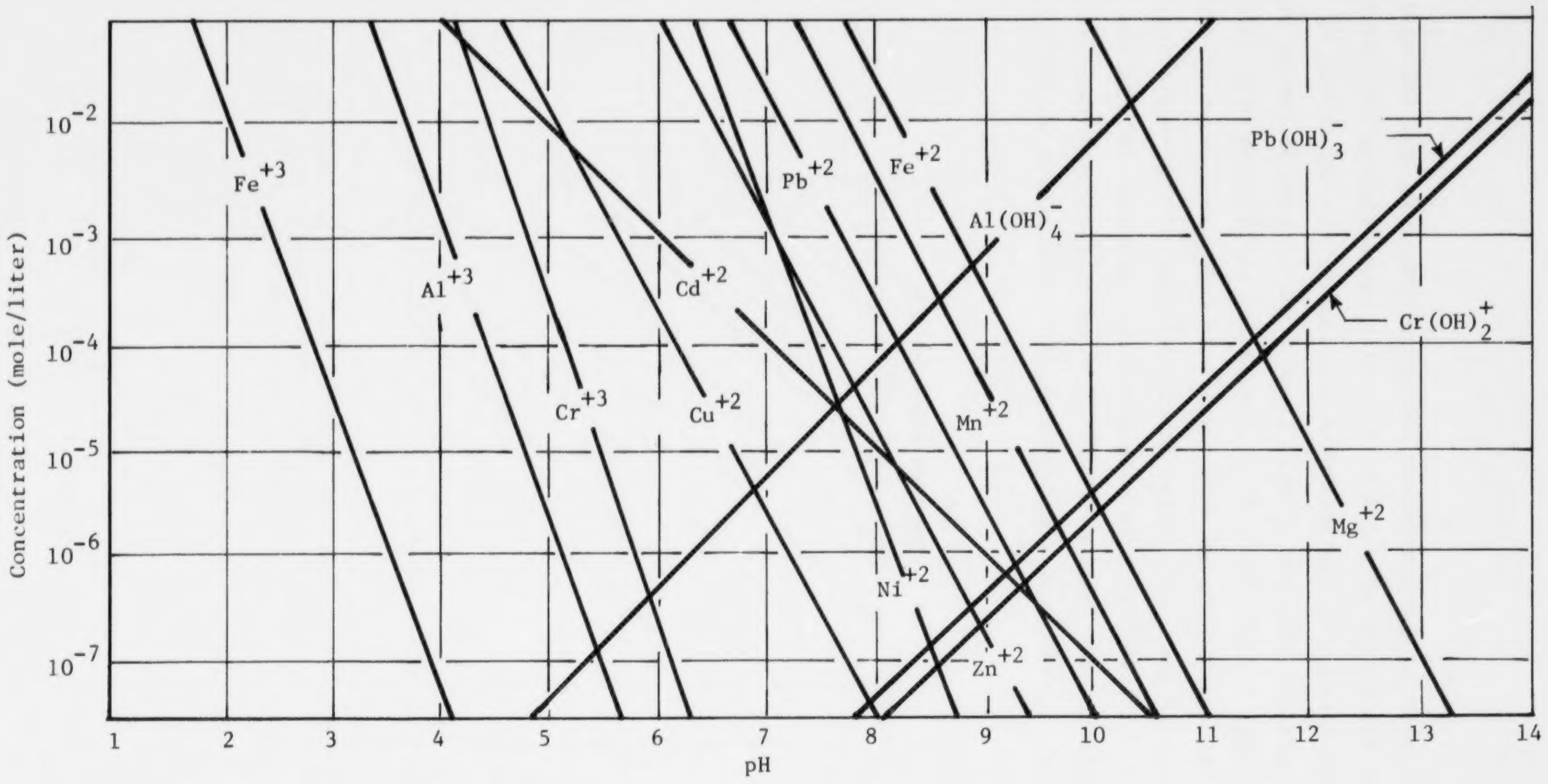

FIGURE 35. SOLUBILITIES OF SOME METALS SHOWING DEPENDENCE ON pH AT 25 C

Calcium Chemistry

In a system open to the atmosphere and containing less than 400 mg/l of sulfate, the solubility of calcium is usually controlled by the precipitation of calcium carbonate. As mentioned previously, the solubility of calcium is much greater than the solubility of iron. Figure 36 can be used to determine whether a given water is in saturation equilibrium with calcium carbonate. Waters undersaturated with respect to $CaCO_3$ at a given pH and bicarbonate concentration* fall in the lower left side of the saturation lines and waters which tend to precipitate calcium carbonate fall in the upper right portion of the figure. Competition effects between cations for the carbonate ion have not been considered in the construction of the diagram.

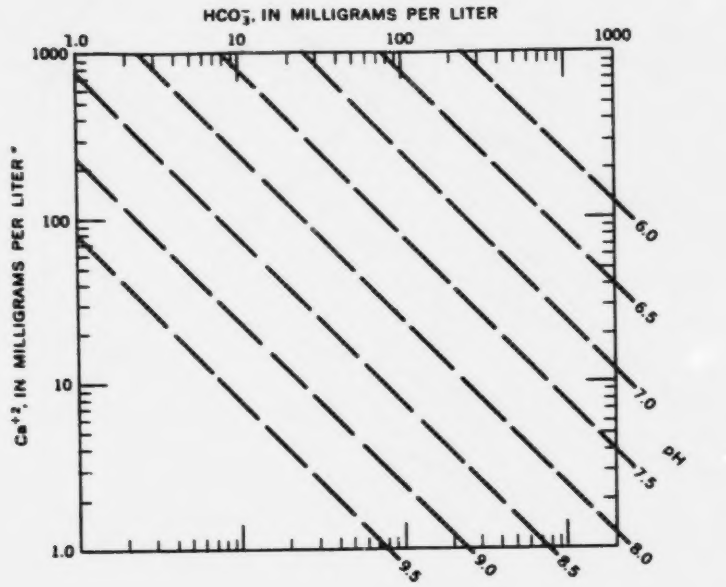

FIGURE 36. EQUILIBRIUM pH IN RELATION TO CALCIUM AND BICARBONATE ACTIVITIES IN SOLUTION IN CONTACT WITH CALCITE

Total pressure 1 atmosphere; temperature 25 C.

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* At pH values less than 9, [alkalinity] [HCO_3^-].

Buffer Capacity

The ability of a natural water to resist large changes in pH as a result of inputs of acidic or basic wastes is of fundamental importance to an assessment of quality. In quantitative terms the buffer capacity is defined as the amount of fully dissociated acid, C_A, to produce a unit change in pH. If the major buffering species in the system are the carbonates, then the buffer capacity, β, can be defined in terms of species contributing to alkalinity and electroneutrality considerations [Reaction (7)]:

$$\beta = 2.3 \left\{ (H^+) + (OH^-) + \frac{C_T(H^+/K_1 + K_2H^+ + 4K_2/K_1}{(1 + H^+/K_1 + K_2/H^+)^2} \right. \qquad (7)$$

where C_T refers to the total carbonate concentrations and K_1 and K_2 are, respectively, the first and second ionization constants of carbonic acid. Reaction 7 can be rearranged to yield an expression [Reaction (8)] for buffer capacity in terms of the alkalinity (in milliequivalents/liter) and pH:

$$\beta = 2.3 \frac{(Alk - OH^- + H^+)(H^+ + K_1K_2/H^+ + 4K_2)}{(1 + 2K_2/H^+)(H^+ + K_1K_2/H^+ + K_1)} \quad . \qquad (8)$$

It should be noted that alkalinity contributing species may also include silicates and borates; however, these should be minor contributors in this system.

Water Quality Analyses

Parameters Monitored

The parameters monitored are listed in Table 4. Not all parameters were monitored at every site and during every campaign. Sites are identified and located in Figure 6.

Samples of the source coals and the material at the ash disposal area were analyzed and the results confirmed the belief that an appropriate set of parameters had been selected (Tables 44 and 45). The coal analyses indicate that the coal presently used at Homer City exhibits generally higher contaminant levels, both trace and macro, than the average of the 101 coals analyzed by the Illinois Geological Survey.(C-3) Of interest are the high concentrations of

TABLE 44. CHEMICAL COMPOSITION OF COALS

	Analyses, percent						
Element	Cambria, Pa.(a)	Wash. Co., Pa.(a,b)	All Coals(a)	Upper Freeport(c)	Helen(e)	Helvetia(e)	Trucked Coal(e)
Al	2.66	1.14	1.29	--	2.74	2.92	2.61
Sb	0.9	0.9	1.26	(1.28)(d)	25	25	25
As	27.0	6.7	14.0	32.8 (43.7)(d)	27	23	49
Ba	--	--	--	44.1	105	121	258
Be	1.1	1.3	1.6	0.4	2.6	2.6	2.6
Cd	0.5	0.2	2.5	--	0.1	0.1	.27
Cr	18	18	13.8	19.8	36	34	31
Co	7	12	9.5	15	15	15	14
Cu	26	11	15	8	27	32	21
Fe	1.06	0.93	1.92	--	2.83	1.87	5.03
Pb	18	7	34.8	4	12.3	15.5	17.8
Mg	0.06	0.04	0.05	--	0.15	0.14	0.10
Mn	14	12	49.4	13	65	36	76
Hg	0.28	0.14	0.20	((.27)(d)	0.47	0.35	1.1
Ni	16	20	21.1	12	16.2	17.5	13.2
Ti	0.15	0.07	0.07	--	0.12	0.12	0.14
V	52	46	32.7	23	62	58	57
Zn	35	21	272.3	19	47	69	66
F	72	52	61	88.7	101	112	94
Se	6.6	1.3	2.1	--	2.1	2.9	6.4
TOS(f)	1.53	1.29	3.27	--	3.02	1.97	5.85

(a) Reference C-3.
(b) Washed coal.
(c) Reference C-4 (ash analysis back calculated to yield whole coal concentrations).
(d) Reference C-5.
(e) This study.
(f) Total sulfur.

TABLE 45. ANALYSES[(a)] OF ASH FROM ASH DISPOSAL AREA AT HOMER CITY COMPLEX

	Campaign I	Campaign II	Campaign III	Mean (Dry Weight Basis)	
				Arithmetic	Geometric
Moisture, percent	11.9	12.6	11.9	--	--
Volatile solids, percent	0.59	3.6	3.8	2.14	2.00
Oil and grease	<100	97	209	135	127
COD	35,000	13,626	98,180	48,935	36,043
TOC	10,900	21,600	19,782	17,427	16,700
$SO_4^=$	98	156	439	231	189
$S^=$	480	405	424	436	435
B	9.7	1.4	--	5.55	3.69
As	5.0	3.8	5.4	4.7	4.7
Cd	<1.0	0.6	<1	0.9	0.8
Cr	112	144	117	124	124
Cu	126	90	92	103	101
Fe	112,500	112,000	11,200	78,567	52,063
Hg	0.14	<0.10	<0.005	0.0815	0.0398
Ni	71	71	75	72	72
Zn	40	59	73	57	56
Pb	12	14	12	13	13
pH	8.74	8.12	7.44	--	--

(a) Values given in parts per million (μg/g dry weight) unless otherwise indicated.

arsenic, beryllium, chromium, mercury, vanadium, and fluorine. Selenium is also relatively high in the Josephine coal. On the other hand, zinc, cadmium, and lead occurred in Homer City coals in lower concentrations than the Illinois Geological Survey average.

Grab samples of material from the ash disposal area were also analyzed. This material was the ash from recently combusted coal, not the ash from whole coal. It is doubtful that these analyses are truly representative of the entire ash emplacement because of its large volume, but the standard deviation for the trace toxic metals and nonmetals indicates a small variation in composition over a 5-month period. Table 46 shows the ratio of the concentration in the ash to the concentration in the coal for seven trace components. The least volatile elements, Cr, Cu, and Ni, tend to be concentrated in the ash, while the more volatile ones such as Hg and As are depleted relative to the raw coal. The washed coal is expected to show a different distribution of trace elements, with some of the elements now appearing in the ash in high concentrations being transferred to the coal refuse disposal area due to their affinity for the sink fraction of the washed coal.(C-3)

TABLE 46. CONCENTRATION RATIOS FOR SELECTED METALS AND NONMETALS IN HOMER CITY ASH AND COAL SAMPLES

Element	Coal, ppm	Ash, ppm	Concentration Ratio
As	32.2	4.7	0.14
Cr	33.8	124	3.8
Cu	26.9	102.7	3.8
Pb	15.1	12.7	0.84
Hg	0.62	< 0.08	< 0.13
Ni	16.4	72.3	4.4
Zn	60.4	57.3	0.95

Sampling and Analysis Techniques

Field Sampling Techniques. Sites for water quality and sediment analyses were determined in advance of field monitoring. Watersheds were sampled from downstream to upstream. All sites within each watershed were sampled on the same day or on two consecutive days. A total of 50 surface and groundwater sites were visited during Campaign I and 27 during Campaigns II and III.

Samples were collected by two two-man teams. As each site was visited, the location number, date, time, field analyses, and other pertinent observations were recorded.

All samples were collected in prewashed polyethylene bottles and glass jars. The two methods used to obtain the samples were (1) grab sampling and (2) the use of an automatic sampler.

The grab sampling technique consisted of submerging each of the containers, yet keeping them as close to the surface as possible to prevent disturbing the bottom sediment, as most streams were very shallow.

At two of the sites, automatic composite samplers were used (Instrumentation Specialties Company, Model 1580). Due to the location of these sites, the quality of the water is more variable than at the other sites. In order to obtain a representative specimen, an approximately 750-ml sample of the water was withdrawn from the stream at 60- to 90-minute intervals for 6, 12, or 24 hours. During the winter (Campaigns I and II) the ambient temperature was low enough to keep the sample cold, but during Campaign III it was necessary to pack the outer jacket of the sampler in ice.

At each site while the sample was being collected, additional data were recorded. A Yellow Springs Instrument Company polarographic D.O. meter was used to measure the dissolved oxygen content and temperature. A Beckman Solu-Bridge was used for specific conductance determinations. Current measurements were taken with a Price-type current meter (Pygmy meter) at selected surface water sites. Flow was calculated using the velocity-area method. Area determinations were made reading the depth off the current meter rod and measuring the width. Flow values should be considered estimates.

Depending on the location, three types of samples were obtained: surface water, groundwater, and/or sediment. Surface water sampling included grab sampling and on-site analysis. During surface water sampling, ancillary data regarding the physical conditions of the stream and surrounding area were also recorded. Groundwater samples were obtained from several piezometers emplaced by D'Appolonia Engineering or from wells, using a small plastic hand pump.

Sediment samples were obtained from several stream beds around the site. Sediment was defined as any material that would pass through a 10-mesh screen. There was some difficulty in obtaining an adequate sample at some sites because the stream bed was composed largely of gravel (see Analytical Techniques).

Preservative was added to each collected sample immediately following the morning or afternoon period of their collection. With the exception of ferrous iron, water samples were preserved using the procedures suggested by the U.S. Environmental Protection Agency.(C-13) Ferrous iron samples were preserved with 4 ml HCl/100 ml sample. Sediment samples were maintained at 4 C until analyzed.

Analytical Techniques. The methods used to analyze the parameters in the water and sediment samples collected during Campaigns I, II, and III are listed in Tables 47 and 48.

The iron, nickel, and chromium values for the sediment samples composed mostly of gravel may be biased high due to the possibility of contamination from the blender blades used to homogenize the sample. This is probably not significant for iron.

Cation/anion balances were run to check the laboratory results. Duplicate analyses were routinely run on every tenth sample to assure continued good precision.

Data

Data obtained for water and sediment samples from Cherry Run Basin, Wier's Run, and Two Lick Creek are given in Tables 49 through 70.

TABLE 47. ANALYTICAL TECHNIQUES FOR WATER SAMPLES

Parameter	Reference	Method
pH	(a)	Electrometric
Acidity	(a)	Potentiometric Titration
Alkalinity	(a)	Potentiometric Titration
Sulfate	(a)	Turbidimetric
Chloride	(a)	Potentiometric Titration
Fluoride	(a)	Distillation and Ion Selective Electrode
Solids	(a)	Gravimetric
Suspended Dissolved Total Volatile		
Sulfide	(b)	1. Methylene Blue - Colorimetric 2. Titration
Ammonia Nitrogen	(c)	Ion Selective Electrode
Kjeldahl Nitrogen	(a)	Ion Selective Electrode
Nitrate Nitrogen	(a)	Brucine Sulfate
Nitrite Nitrogen	(c)	N-(1-naphthyl)-ethylene diamine dihydrochloride
Total Phosphorus	(c)	Ascorbic Acid
Phenol	(a)	4-Amino Antipyrene
C.O.D.	(c)	Dichromate Oxidation
T.O.C.	(a)	Beckman T.O.C. Analyzer/IR
Specific Conductance	(a)	Conductivity Bridge
Chromium	(a)	Diphenylcarbazide
Mercury	(c)	Persulfate/Sulfuric Acid Digestion Flameless AAS
Ferrous Iron	(a)	1-10 Phenanthroline
Metals	(a)	Persulfate/Sulfuric Acid Digestion Silver Diethyl Dithiocarbamate
Arsenic Beryllium Calcium Cadmium Copper		

TABLE 47. (Continued)

Parameter	Reference	Method
Metals (continued)		
Lead Magnesium Manganese Nickel Potassium Sodium Vanadium Zinc		
Dissolved Metals (except Hg)	(c)	Filtered Flameless AAS
Total Metals (except Hg) (except Hg)	(c)	Digestion AAS
Oil and Grease	(a)	Liquid/Liquid Ether Extraction
Samples Containing Coal Fines	(d)	Digestion with Perchloric Acid/ Hydrofluoric Acid Mixture

(a) Reference C-13.

(b) Reference C-14.

(c) Reference C-12.

(d) Reference C-18.

TABLE 48. ANALYTICAL TECHNIQUES FOR SEDIMENT SAMPLES

Parameter	Reference	Method
% Water	(a)	Gravimetric
Volatile Solids	(a)	Gravimetric
Oil and Grease	(a)	Freon-Soxhlet Extraction after Drying with $MgSO_4 \cdot H_2O$
C.O.D.	(a)	Potassium Dichromate Digestion
Sulfide	(a)	Distillation and Colorimetric
Sulfate	(b)	Extraction and Turbidimetric
pH	(c)	pH meter
T.O.C.	(c)	Beckman T.O.C. Analyzer
Total Inorganic Carbon	(c)	Beckman T.O.C. Analyzer
Boron	(b)	Na_2CO_3 Fusion and Curcumin Colorimetric
Mercury	(c)	Acid Persulfate, Permanganate Digestion: Flameless AAS
Metals Magnesium Potassium Calcium Sodium Cadmium Chromium Copper Nickel Zinc Lead Iron Manganese Arsenic	(c)	Nitric, Perchloric and Hydrofluoric Acid Digestion Followed by AAS

(a) Reference C-16.

(b) Reference C-17.

(c) Reference C-13.

(d) Reference C-11.

TABLE 49. SURFACE WATER ANALYSES FOR CHERRY RUN BASIN--PART 1: CHEMICAL CONTROLS ON SOLUBILITY(a)

Site(b)	Acidity, as $CaCO_3$	pH	Total Fe	Dissolved Fe	Fe^{2+}	Mn	Ca	Alkalinity, as $CaCO_3$	SO_4
Campaign I									
H1	7.2	6.7	1.71	0.10	0.42	0.28	18.2	32.0	37.5
H3	1.8	6.1	1.50	0.76	0.76	0.28	19.8	16.3	64.9
H6	3.8	6.7	0.26	0.09	0.19	0.21	37.2	16.3	244
CDE 1	175	3.8	3.20	2.93	0.80	22.0	162	0	901
H8	6.2	6.1	1.20	0.12	0.17	2.24	40.8	6.0	258
H7	1.7	6.5	0.20	0.05	0.17	<0.02	7.20	9.8	22.6
H13	3.6	6.5	0.66	0.06	0.14	1.40	31.2	8.9	189
H14	7.8	6.1	0.95	0.27	0.14	0.46	23.6	18.3	83.6
Campaign II									
H1	3.3	7.0	0.54	<0.02	0.38	0.07	17.4	21.1	32.2
H3	4.3	7.0	1.99	0.44	<0.10	0.20	16.5	13.2	44.2
H6	1.4	6.6	0.53	0.03	<0.10	0.13	19.2	12.6	115
H8(c)	1.8	6.7	1.27	0.03	<0.10	0.16	19.7	14.2	97
CDE 1	13.2	4.5	1.30	1.20	<0.10	14.1	122	0	630
H7	1.4	6.5	0.30	0.04	<0.10	0.02	7.70	7.1	26.4
H13	2.0	6.4	0.59	0.02	<0.10	0.90	23.2	7.1	111
H14	4.5	6.7	0.98	0.18	<0.10	0.29	17.3	14.0	51.2
Campaign III									
H1	1.4	7.6	0.14	<0.02	<0.10	0.02	20.3	44.2	27.3
H3	3.9	7.1	0.36	<0.02	<0.10	0.27	22.2	25.4	73.6
H6	3.3	7.9	0.08	<0.02	<0.10	0.16	38.9	19.6	267
H8(c)	3.7	6.7	0.17	<0.02	<0.10	0.09	35.0	23.4	208
CDE 1	56.3	4.8	1.93	1.34	<0.10	13.5	13.8	2.2	1586
H7	4.3	6.6	0.27	<0.02	<0.10	0.02	7.2	10.5	20.6
H13	3.7	7.5	0.27	<0.02	<0.10	0.87	37.2	15.7	204
H14	1.4	7.2	0.14	<0.02	<0.10	0.02	20.3	44.2	27.3

(a) Values in mg/l except pH.
(b) See Figure 6 for water sampling site locations.
(c) Relocated upstream from discharge of emergency holding pond.

TABLE 50. GROUNDWATER ANALYSES FOR CHERRY RUN BASIN--
PART 1: SOLUBILITY CONTROLLING SPECIES(a)

Site(b)	pH	Total Fe	Dissolved Fe	Fe^{2+}	Suspended Solids	Mn	Ca	Alkalinity as $CaCO_3$	SO_4
Campaign I									
CDE 5	4.1	9.6	9.2	1.76	16.8	10.5	99.8	2.6	509
CDE 7	2.7	1300	1720	373	25.4	229	497	0	7353
H9	7.1	380	0.12	5.60	-	9.16	315	-	-
H11	4.8	680	88.0	5.70	5876	10.90	49.2	12.6	29.4
Campaign II									
CDE 5	3.9	11.8	-	1.42	3.2	17.3	159	0	722
CDE 7	2.3	620	620	56.7	72.0	76	329	0	3812
H 9	7.5	454	0.13	2.03	20,100	10.4	306	563	36.9
H 11	6.1	810	1.67	2.46	13,960	19.1	80	67.4	32.8
Campaign III									
CDE 5	------------------------------ No Sample --------------------------------								
CDE 7	2.7	1300	1300	213	4.0	96	298	0	5574
H 9	6.9	143	0.05	3.10	1,370	3.35	82	71.4	22.8
H 10	7.9	153	0.03	1.62	-	5.23	94.5	-	-
H 11	5.4	47.5	1.92	0.99	5,105	2.03	12.8	5.6	35.1

(a) Values in mg/l except pH.
(b) See Figure 6 for water sampling site locations.

TABLE 51. COMPARISON OF WATER QUALITY AT STATIONS H14 AND H16 ON CHERRY RUN ABOVE AND BELOW MINE BOREHOLE DISCHARGES (CAMPAIGN I)(a)

Parameters	Site H14	Site H16
pH	6.1	6.9
Acidity, as $CaCo_3$	7.8	7.2
Alkalinity, as $CaCo_3$	18.3	19.5
Sulfate	83.6	114.
Iron, total	0.95	4.40
Iron, dissolved	0.27	4.38
Iron, ferrous	0.14	0.77
Calcium	23.6	29.2
Manganese	0.46	0.49

(a) Values in mg/l except pH.

TABLE 52. SURFACE WATER ANALYSES FOR CHERRY RUN BASIN-- PART 2: TRACE MATERIALS

Site[c]	Concentrations[a]									
	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	V	Be
H1	n.d.[b]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.
H3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.
H6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.05	n.d.	n.d.
H8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	0.30	n.d.
CDE1	n.d.	0.003	n.d.	0.03	n.d.	n.d.	0.34	0.63	n.d.	n.d.
H7	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.03	n.d.	n.d.
H13	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.05	n.d.	n.d.
H14	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
H16	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Reference Stream	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	--	--

(a) Concentrations are means in mg/l; values less than the analytical detection limit were averaged as one-half the detection limit.

(b) n.d. = not detected. Detection limits in mg/l are: As 0.005; Cd 0.001; Cr 0.02; Cu 0.02; Pb 0.005; Hg 0.0005; Ni 0.005; Zn 0.02; V 0.25; Be 0.02; and Phenols 0.005.

(c) See Figure 6 for water sampling site locations.

TABLE 53. SEDIMENT ANALYSES(a)--CHERRY RUN

	Sediment Site No.(b)	Fe, %	TOC, %	pH, Units	$S^{=}$, mg/kg	$SO_4^{=}$	V.S. %	Mn	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
												mg/kg				
Campaign I	H4 (H3)	3.24	1.33	6.46	< 21	96	5.80	796	9.5	< 1.0	173	30	21	0.10	90	75
	CDE2 (CDE1)	6.87	2.08	4.10	< 20	2194	6.07	1280	13	< 1.0	183	107	20	< 0.16	100	172
	H15 (H14)	5.32	1.78	6.89	< 44	125	4.32	2830	13.3	< 1.0	346	110	19	0.25	207	107
	H17 (H16)	4.37	1.27	6.45	< 20	80	5.55	7620	8.4	< 1.0	180	85	9.0	< 0.10	126	106
Campaign II	H4 (H3)	4.85	0.20	6.91	< 9	201	3.31	1260	6.4	0.5	250	90	26	0.10	140	120
	H12 (H6)	3.55	0.21	6.38	< 7	208	2.94	612	6.6	0.5	225	310	36	< 0.10	130	244
	CDE2 (CDE1)	6.40	3.35	4.48	< 6	1414	4.01	1380	9.4	0.5	152	85	41	< 0.10	120	137
	H15 (H14)	2.43	1.10	6.66	< 16	223	4.56	950	5.6	0.6	86	23	26	< 0.10	86	119
	H17 (H16)	2.97	0.40	6.26	< 7	64	3.32	600	10.0	0.5	248	81	24	< 0.10	132	120
Campaign III	H4 (H3)	7.10	0.27	6.89	6	52.5	4.70	248	15	1.0	135	440	50	0.017	103	387
	H12 (H6)	4.32	0.31	7.22	9	397	2.69	1430	9.6	1.0	157	120	63	0.016	115	677
	CDE2 (CDE1)	3.85	1.45	5.20	8	1470	6.41	702	9.6	1.0	75	475	37	0.044	44	293
	H15 (H14)	2.56	0.21	6.72	4	255	1.46	1370	4.8	1.0	84	225	28	0.010	71	190

(a) All values on a dry weight basis
(b) Associated water sampling site at same location in parentheses. See Figure 6.

TABLE 54. GRANULOMETRY--CHERRY RUN BASIN
(All Values in Percent)

Grain Size Range	Site:(a) Campaign:	H3 II	H6 II	CDE1 II	H14 II	H16 II	H3 III	H6 III	CDE1 III	H14 III	H16 III
Gravel (> 4.76 mm)		11.1	0	37.3	5.2	2.1	10.0	29.1	35.5	0	0
Sand (0.42-4.76 mm)		43.8	27.3	37.3	9.8	21.7	74.9	52.7	33.3	55.7	0.3
Fine sand (0.074-0.42 mm)		35.5	64.2	10.8	52.0	44.0	10.3	15.7	20.7	42.2	6.4
Silt (0.002-0.074 mm)		9.6	8.5	14.6	25.0	26.5	4.8	2.5	10.5	2.1	68.7
Clay (< 0.002 mm)					8.0	5.7					24.6

(a) See Figure 6 for water sampling site locations.

TABLE 55. TRACE METALS IN GROUNDWATER NEAR CHERRY RUN[(a)]

	CDE5[(c)]		CDE7[(d)]		H9[(e)]		H11[(f)]	
Metals	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
As	n.d.[(b)]	n.d.	0.093	0.158	n.d.	0.164	n.d.	0.212
Cd	n.d.	0.002	0.023	0.061	n.d.	0.004	n.d.	0.008
Cr	n.d.	n.d.	0.14	0.20	n.d.	0.30	n.d.	0.52
Cu	n.d.	0.21	1.19	2.00	n.d.	0.29	n.d.	0.44
Pb	0.012	0.011	0.05	0.13	n.d.	0.32	n.d.	0.45
Hg	n.d.	n.d.	n.d.	n.d.	n.d.	0.0006	0.0007	0.0007
Ni	0.15	0.14	2.18	2.86	n.d.	0.26	n.d.	0.43
Zn	0.15	0.15	4.56	6.68	n.d.	0.78	0.07	1.53
V	--	n.d.	--	n.d.	n.d.	n.d.	n.d.	0.46
Be	--	n.d.	0.06	0.07	n.d.	n.d.	n.d.	0.03

(a) Values in mg/l.
(b) Not detected; see Table 51 for detection limits.
(c) pH = 3.9-4.1.
(d) pH = 2.3-2.7.
(e) pH = 6.8-7.5.
(f) pH = 4.8-6.1.

TABLE 56. SURFACE WATER ANALYSES FOR CHERRY RUN BASIN-- PART 3: NUTRIENTS AND SOLIDS[(a)]

Station[(b)]	TP	SS	VS	NO_3^--N	TKN	TOC	NH_3-N	Total Solids
				Campaign I				
H1	0.10	9.6	43	1.42	0.34	1.2	<0.05	159
H3	0.02	8.8	31	2.0	0.20	2.4	0.08	178
H6	0.03	7.6	50	0.75	0.16	2.8	0.05	430
CDE1	<0.01	7.6	169	0.62	0.37	6.0	0.19	1500
H8	<0.01	31.2	41	0.50	0.25	2.5	<0.05	450
H7	0.02	12.4	20	0.40	0.15	2.2	<0.05	82
H13	0.04	17.2	45.0	0.57	<0.05	1.2	<0.05	352
H14	0.03	7.2	34	1.63	0.14	1.7	0.08	181
				Campaign II				
H1	0.06	10.0	48.0	1.32	0.21	1.4	0.06	124
H3	0.04	9.6	28.0	1.85	0.31	2.8	0.05	133
H6	0.02	10.8	36.0	1.0	0.27	1.5	<0.05	180
H8	0.08	31.6	53.0	1.08	0.20	2.0	<0.05	224
CDE1	0.01	14.8	182	0.88	0.41	4.5	0.17	1087
H7	0.02	8.4	19.0	0.50	0.10	2.0	<0.05	82
H13	0.05	29.8	42.5	1.07	0.12	1.7	<0.05	233
H14	0.04	14.0	4.0	1.58	0.25	2.0	0.06	156
				Campaign III				
H1	0.01	1.2	7.0	0.36	<0.05	2.0	<0.05	124
H3	0.01	2.0	17.0	1.1	0.14	3.5	<0.05	183
H6	0.01	1.2	30.0	0.50	0.12	3.5	<0.05	442
H8	0.02	2.4	24.5	0.34	0.4	4.4	<0.05	378
CDE1	<0.01	13.2	122	0.68	0.24	2.5	0.17	1232
H7	0.01	11.6	5.0	<0.1	0.16	3.5	<0.05	112
H13	0.01	6.8	9.0	0.44	<0.05	4.0	<0.05	380
H14	<0.01	2.4	2.0	0.76	0.36	4.0	<0.05	124

(a) Values in mg/l. TP = total phosphorus, SS = suspended solids, VS = volatile solids, NO_3^--N = nitrate nitrogen, TKN = total Kjehldahl nitrogen, TOC = total organic carbon, NH_3-N = ammonia nitrogen.

(b) See Figure 6 for water sampling site locations.

TABLE 57. SURFACE WATER QUALITY IN WEST TRIBUTARY TO WIER'S RUN--SOLUBILITY OF IRON, MANGANESE, AND CALCIUM

Parameter	Site F9	Site F11
pH	7.6	7.3
Alkalinity, mg/l as $CaCO_3$	54.2	31.2
Sulfate, mg/l	30.4	33.9
Calcium, mg/l	26.2	18.2
Iron, ferrous, mg/l	<0.10	<0.10
Iron, total, mg/l	0.27	2.45
Iron, dissolved, mg/l	0.10	0.10
Manganese, mg/l	0.02	0.18

TABLE 58. SURFACE WATER ANALYSES FOR WIER'S RUN--PART 1: SOLUBILITY CONTROLLING SPECIES(a)

	Site(b)	Acidity, as $CaCO_3$	pH	Total Dissolved					Alkalinity, as $CaCO_3$	SO_4^{-}
				Fe	Fe	Fe^{2+}	Mn	Ca		
Campaign I	F4	7.0	7.3	0.19	0.77	0.11	0.09	3.99	10.5	14.3
	F6	92.7	4.9	19.5	17.7	2.85	5.70	148	5.6	789
	F12	42.2	5.9	15.0	13.0	2.14	6.10	174	34.4	836
	F14	19.4	6.7	11.1	6.90	0.12	2.27	224	14.2	1713
	F17	9.5	7.0	7.73	4.04	0.19	2.52	208.5	18.0	1360
Campaign II	F4	1.6	5.6	0.24	0.03	<0.1	0.43	4.70	6.5	17.3
	F6	91.4	5.0	16.9	16.2	1.67	4.47	124	2.4	540
	F12	45.7	4.9	12.8	12.2	0.91	4.67	124	11.0	555
	F14	0	7.1	1.02	0.02	0.1	0.43	198	42.2	1305
	F17	7.1	5.8	3.80	2.00	0.14	1.47	86	20.5	460
Campaign III	F4	15.3	6.5	1.37	0.08	<0.1	0.13	3.71	7.7	14.2
	F6	72.4	4.9	16.6	15.8	2.05	4.62	145	3.8	696
	F12	17.2	6.5	8.40	7.10	0.64	4.00	151	60.1	670
	F14	3.9	8.0	2.19	<0.02	<0.1	0.38	226	31.0	1450
	F17	3.1	7.6	1.82	0.02	<0.1	1.40	166	49.2	905

(a) Values in mg/l except pH.

(b) See Figure 6 for water sampling site locations.

TABLE 59. SURFACE WATER ANALYSES FOR WIER'S RUN--PART 2: TOXIC MATERIALS[a]

Site[d]	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	V	Be	Phenols
F3	n.d.[b]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	--	--	n.d.
F4	0.005	n.d.	n.d.	n.d.	0.005	n.d.	n.d.	0.02	n.d.	n.d.	0.013
F6	0.014	0.001	n.d.	n.d.	n.d.	n.d.	0.13	0.16	n.d.	n.d.	n.d.
F7	0.013	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	--	--	n.d.
F8	n.d.	0.004	n.d.	n.d.	n.d.	n.d.	0.26	0.49	--	--	0.009
F12	0.008	n.d.	n.d.	n.d.	n.d.	n.d.	0.10	0.12	n.d.	n.d.	n.d.
F9	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	--	--	0.006
F11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	--	--	0.007
F14	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.06	0.08	n.d.	n.d.	n.d.
F17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.07	0.09	n.d.	n.d.	0.010
Ash Analysis[c]	4.7	0.9	124	103	13	.081	72	47	--	--	--

(a) Values in mg/l.

(b) n.d. = not detected; see Table 52 for metal and non-metal detection limits; detection limits for phenol = 0.005 mg/l; values less than detection were included in mean as one-half the detection limit.

(c) Ash analysis in mg/kg dry weight basis.

(d) See Figure 6 for water sampling site locations.

TABLE 60. SEDIMENT ANALYSES FOR WIER'S RUN

Sediment Site Number (Associated Water Sampling Site Number)*	Fe, %	T.O.C., %	pH, units	$S^{=}$**	$SO_4^{=}$**	Volatile Solids, %	Mn**	As**	Cd**	Cr**	Cu**	Pb**	Hg**	Ni**	Zn**
						Campaign I									
F2(F4)	3.88	1.94	6.34	<46	139	8.17	1095	9.25	<1.0	66	39	20.5	0.24	41	109.5
F13(F12)	4.15	1.28	6.73	<15	298	4.06	349	19	<1.0	156	25	2.0	0.14	79	65
F18(F17)	3.71	1.44	7.11	50	931	5.89	500	11.2	<1.0	105	45	19	0.15	105	88.8
						Campaign II									
F2(F4)	4.67	0.35	6.63	<26	1840	8.08	1700	8.0	0.3	383	194	47	0.20	210	170
F13(F12)	4.13	0.21	6.93	<5	444	3.71	630	9.2	0.2	197	48	29	<0.1	115	87
F18(F17)	3.29	0.20	6.65	<5	267	3.13	1000	7.6	0.4	102	27	21	<0.1	71	85
						Campaign III									
F2(F4)	3.78	1.97	5.72	<5	948	6.63	550	41	<1	128	178	30	0.045	89	172
F13(F12)	4.10	2.56	7.16	<5	1420	6.38	450	12	<1	172	169	26	0.034	117	147
F18(F17)	3.33	0.18	7.15	5	953	2.55	825	8.4	<1	136	270	28	0.024	97	210

* Associated water sampling site at same location in parentheses. See Figure 6.

** mg/kg.

TABLE 61. SEDIMENT GRANULOMETRY FOR WIER'S RUN[a]

Grain Size, mm	Campaign II F4	Campaign II F12	Campaign II F17	Campaign III F4	Campaign III F12	Campaign III F17
Gravel (>4.76)	4.0	10.2	0	0	0.1	10.3
Sand (0.42-4.76)	25.7	22.3	65.3	2.8	50.7	42.6
Fine Sand (0.076-0.42)	27.4	43.1	22.9	14.9	45.4	40.6
Silt (0.002-0.074)	} 42.9	18.4	} 11.8	16.7	} 3.8	} 6.5
Clay (<0.002)		6.0		14.6		

(a) Percent contained in each size range.

TABLE 62. SURFACE WATER ANALYSES FOR WIER'S RUN-- PART 3: NUTRIENTS AND SOLIDS[(a)]

	Site	Total P	Susp. Solids	Volatile Solids	NO_3-N	TKN[(b)]	T.O.C.	NH_3-N	Total Solids
Campaign I	F4	0.02	6.0	3	1.14	0.31	2.85	<0.05	55
	F6	<0.01	17.6	109	0.72	0.57	<1.0	0.31	1,287
	F12	<0.01	20.7	93	0.74	0.47	<1.0	0.41	1,351
	F14	<0.01	24	157	0.54	0.88	1.9	0.71	2,719
	F17	<0.01	35.3	115	0.66	0.95	2.45	0.63	2,119
Campaign II	F4	0.01	1.2	15.0	0.84	0.33	1.0	<0.05	56.0
	F6	<0.01	13.2	95.0	1.04	0.25	<1	0.21	928
	F12	<0.01	15.0	103	0.90	0.60	<1	0.21	924
	F14	<0.01	13.2	132	0.54	0.68	1.0	0.59	2,112
	F17	0.01	29.3	88.0	1.26	0.27	3.1	0.18	818
Campaign III	F4	0.01	20.8	1.0	0.54	0.10	3.5	<0.05	80.0
	F6	0.01	14.5	30.0	0.50	0.12	3.5	<0.05	1,129
	F12	<0.01	18.0	60	0.52	0.36	7.0	0.21	1,163
	F14	<0.01	14.4	83.0	0.28	0.40	3.0	0.35	2,307
	F17	0.01	11.2	81.0	0.58	0.40	3.0	0.28	1,521

(a) Values in mg/l.
(b) Total Kjeldahl nitrogen.
(c) See Figure 6 for water sampling site locations.

TABLE 63. SURFACE WATER ANALYSES FOR COMMON RAVINE/SECOND RAVINE-- PART 1: SOLUBILITY CONTROLS(a)

	Site(c) No.	Campaign	Acidity	pH (units)	Total Fe	Diss. Fe	Fe^{2+}	Mn	Ca	Alk.	SO_4	Composite Sampling Conditions		
												Frequency, min	Duration, hr	Instantaneous Flow, cfs
					A. Common Ravine									
	CDE 17	I	0	8.9	7.93	0.02	< 0.10	0.68	102.5	51.0	290	90	10	2.5
	CDE 17	II	0	11.4	21.4	0.04	0.37	1.12	485	615	1,180	60	12	---
	CDE 17	III	183	4.8	11.0	8.20	< 0.10	1.76	215	0	920	60	20	2.5
					B. Second Ravine									
	CDE 15	I	140	4.7	47.5	45.7	4.05	6.70	133	2.4	664	90	10	---
	CDE 15	II	605	4.3	191	188	1.10	14.7	148	0	1,237.5	60	10	3.3
	CDE 15	III	1,999	4.9	472.5	453	467	45.2	209	0	2,940	60	6	3
	CDE 16	I	28.3	4.8	8.00	7.90	< 0.10	2.21	113	0	424			
					C. Loading Sources							**Receiving Water**		
Ash Sluice Water Overflow	CDE 12	I	0	9.4	1.73	0.70	< 0.1	0.15	118	34.2	357	Second Ravine		
Coal Pile Runoff (before treatment)	CDE 8	I	7,410	2.4	2,420	2,450	1,595	668	417	0	9,188	Common Ravine/Second Ravine		
	CDE 8	II	10,588	1.9	2,670	2,800	576	211	416	0	10,246			
	CDE 8	III	7,1487,1	2.6	2,300	2,280	1,301	56	355	0	9,180			
Cooling Tower Blowdown Overflow (accidental)		I	5.2	7.4	12.8	0.03	< 0.1	0.89	103	31.8	346	Common Ravine		
Industrial Waste Treatment Plant (IWT)(a)			0	9.4-12.1	2.59	0.09	--	--	--	--	--	Common Ravine		

(a) Values in mg/l unless otherwise noted.
(b) Values obtained by Penelec 9/76 - 11/76.
(c) See Figure 6 for water sampling site locations.

TABLE 64. SURFACE WATER ANALYSES FOR COMMON RAVINE/SECOND RAVINE-- PART 2: TOXIC MATERIALS[(a)]

Site No.[(d)]	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	V	Be	Phenols	Oil & Grease	Cr^{+6}
A. Common Ravine													
CDE13	0.21	0.003	0.14	0.14	0.09	0.0006	0.14	0.69	0.36	n.d.	0.020	--	n.d.
CDE10	0.06	0.002	0.04	0.05	0.03	n.d.	0.06	0.29	n.d.	n.d.	0.030	--	n.d.
CDE17	0.02	0.003	0.02	0.03	0.02	n.d.	0.06	0.23	n.d.	n.d.	0.360	853[(c)]	n.d.
B. Second Ravine													
CDE12	0.47	0.002	n.d.	n.d.	0.005	n.d.	n.d.	0.10	--	--	0.013	--	--
CDE15	0.02	0.002	n.d.	0.06	n.d.	n.d.	0.64	1.73	n.d.	0.02	0.340	--	--
CDE16	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	0.10	--	--	0.009	--	--

(a) Values in mg/l.
(b) Not detected; see Table 52 for detection limits.
(c) Single determination.
(d) See Figure 6 for water sampling site locations.

TABLE 65. SURFACE WATER ANALYSES FOR COMMON RAVINE/SECOND RAVINE-- PART 3: NUTRIENTS AND SOLIDS(a)

Site(c)	Campaign	Total P	Susp. Solids	Volatile Solids	NO_3^--N	TKN(b)	TOC	NH_3-N	Total Solids
CDE17	I	0.14	61.25	74.0	3.08	4.55	19.9	4.2	579.5
	II	< 0.01	64.0	2.58	3.75	3.32	7.25	2.4	2260.5
	III	0.16	968	1,046	0.40	2.2	97.5	1.6	2,441
CDE12	I	0.17	31.6	59	3.3	0.21	4.4	0.17	685
CDE15	I	< 0.01	45.6	123	4.4	0.50	5.0	0.45	1145
	II	< 0.01	156	229	4.35	1.56	24.8	1.0	2,569
	III	< 0.01	63.15	738.5	2.06	17.8	21.5	14.4	4978.5
CDE16	I	< 0.01	23.6	83	3.5	0.51	3.0	0.36	743

(a) Values in mg/l.

(b) Total Kjeldahl Nitrogen.

(c) See Figure 6 for water sampling site locations.

TABLE 66. SURFACE WATER ANALYSES FOR TWO LICK CREEK-- PART 1: SOLUBILITY CONTROLS[a]

	Site No.[b]	Acidity	pH	Total Fe	Diss. Fe	Fe^{2+}	Mn	Ca	Alkalinity	SO_4
Campaign I	H18	34.8	5.3	8.75	8.20	1.36	0.77	27.7	2.7	134
	H19	37.8	4.1	14.3	10.0	1.36	1.20	50.6	3.8	230
	CDE18	62.3	3.2	14.5	12.4	2.06	1.30	37.2	0	209
	CDE19	57.5	4.1	15.0	12.3	0.49	1.28	41.4	2.2	219
Campaign II	H18	31.4	5.2	7.50	4.72	1.17	0.64	21.7	4.9	93
	H19	18.6	4.8	5.67	3.93	0.24	0.55	21.0	3.7	90
	CDE18	35.1	4.7	7.70	5.23	0.58	0.67	22.7	3.2	100
	CDE19	33.7	5.2	8.90	5.32	0.42	0.77	26.2	2.8	112
Campaign III	H18	75.1	3.6	12.9	11.0	0.27	1.21	34.9	0	207
	H19	48.0	4.1	10.2	7.3	0.23	1.12	39.1	0	195
	CDE18	79.0	3.6	11.0	8.7	<0.1	1.23	35.9	0	202
	CDE19	65.4	3.9	11.0	6.9	6.03	1.30	43.9	0	213

(a) Values in mg/l except pH.

(b) See Figure 6 for water sampling site locations.

TABLE 67. SURFACE WATER ANALYSES FOR TWO LICK CREEK-- PART 2: TOXIC MATERIALS[(a)]

Site No.[(c)]	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	V	Be	Phenols
H18	n.d.[(b)]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	n.d.	n.d.	n.d.
H19	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.09	n.d.	n.d.	0.008
CDE18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.10	n.d.	n.d.	0.005
CDE19	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.11	n.d.	n.d.	n.d.

(a) Values in mg/l

(b) n.d. = not detected; detection limits are given in Table 52.

(c) See Figure 6 for water sampling site locations.

TABLE 68. SEDIMENT ANALYSES--TWO LICK CREEK

	Site No.[(a)]	Fe, %	TOC, %	pH, units	$S^=$ mg/kg	$SO_4^=$	Volatile Solids, %	Mn mg/kg	As mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Pb mg/kg	Hg mg/kg	Ni mg/kg	Zn mg/kg
Campaign I	No Sample															
Campaign II	CDE20 (CDE19)	8.05	11.3	5.26	< 9	5,925	17.72	210	10	0.55	152.5	94	48	0.42	79	108
Campaign III	H17 (H18)	8.80	4.96	6.76	636	1,080	17.05	240	20	< 1	90	146	85	0.47	33	207
	CDE20 (CDE19)	1.08	4.63	6.01	1,470	3,385	17.72	251.5	21.5	< 1	108	230	62.5	0.53	40	185

(a) See Figure 6 for water sampling site locations.

TABLE 69. SEDIMENT GRANULOMETRY--TWO LICK CREEK[a]

Grain Size, mm	Upstream (H17) Campaign III	Downstream (CDE 20) Campaign II	Downstream (CDE 20) Campaign III
Gravel (>4.76)	0	0	16.5
Sand (0.42-4.76)	0.3	8.7	4.0
Fine Sand (0.074-0.42)	6.4	47.9	15.6
Silt (0.002-0.074)	68.7	38.9	45.9
Clay (<0.002)	24.6	4.5	18.0

(a) Percent contained in each size range.

TABLE 70. SURFACE WATER ANALYSES FOR TWO LICK CREEK--
PART 3: NUTRIENTS AND SOLIDS

	Site No.[b]	Total P	Suspended Solids	Volatile Solids	NO_3-N	TKN[a]	TOC	NH_3-N	Total Solids
Campaign I	H18	0.17	11.0	36.5	0.27	0.48	2.65	0.84	246
	H19	0.02	34.5	56.0	1.16	0.98	3.2	0.68	438
	CDE18	0.02	14.5	67.	0.83	1.0	3.5	0.77	382
	CDE19	0.03	20.0	76.	1.80	1.25	4.0	1.03	387
Campaign II	H18	0.01	30.7	63.0	0.22	0.52	3.3	1.28	230
	H19	<0.01	27.0	50.0	1.44	0.71	1.8	0.19	205
	CDE18	<0.01	25.0	37.0	1.34	0.35	1.8	0.18	215
	CDE19	0.01	26.0	30.	1.64	0.41	2.5	0.19	233
Campaign III	H18	0.01	5.6	24.0	0.46	0.56	2.5	0.94	329
	H19	0.01	8.8	28.0	1.14	0.6	2.5	0.48	346
	CDE18	0.01	14.0	47.	1.02	0.75	3.0	0.68	353
	CDE19	0.01	27.3	24.	1.02	1.02	6.5	0.62	372

(a) Total Kjeldahl Nitrogen.

(b) See Figure 6 for water sampling site locations.

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APPENDIX D

AQUATIC BIOTA RECONNAISSANCE

Sampling Site Locations and Descriptions

Sampling sites were selected in seven streams in the vicinity of the Homer City power complex: Cherry Run and its north and south tributaries, Wier's Run, Common Ravine, Rager's Pond tributary, and Two Lick Creek. An additional site was sampled in Ramsey Run, a stream some distance from the complex. Fourteen locations were sampled in these streams. Sites were chosen that would provide the best data for evaluating the impact of current plant discharges on the aquatic biota of the receiving streams. Cherry Run and Wier's Run, which are intermediate-size streams, receive most of the drainage from the plant area. These and two small tributary streams, Common Ravine and Rager's Pond tributary, flow into Two Lick Creek, a major tributary to Blacklick Creek. A survey conducted in 1972(D-1) reported poor water quality in Two Lick Creek due to low pH and high sulfates, iron, and total solids. Mine drainage was the probable source of this contamination. On the basis of this report, only a minimal sampling effort was carried out in Two Lick Creek.

A description of the areas sampled and their locations is given in Table 71. The precise locations of these sampling sites are shown on a map of the area surrounding the Homer City power complex (Figure 25). Ramsey Run is not shown on this map. It is a tributary of Two Lick Creek several miles upstream east of Indiana, Pennsylvania, and flows in a southerly direction.

Organisms Selected for Study

Three groups of aquatic organisms were selected for study. Periphyton, benthic macroinvertebrates, and fishes were investigated because of their relative ease of collection, usefulness as indicators of water quality, and importance in the trophic structure of the aquatic community.

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TABLE 71. AQUATIC BIOTA SAMPLING STATIONS

Site[(a)]	Location	Description
1	Cherry Run north of refuse disposal area	Riffle areas 3 to 4 meters wide, up to 0.3 meter deep with cobble-rubble substrate. Pool areas 5 to 6 meters wide and up to 0.8 meter deep with sand gravel pebble substrate. Some silt over substrate. Many trees and stumps and much debris in stream. Closed canopy, with alder, beech, cherry, willow, and hawthorn.
2	Cherry Run upstream from disposal area tributary	Stream was 5 to 6 meters wide and 0.3 to 0.4 meter deep, riffles with gravel-pebble-rubble bottom; run areas had mostly sand and gravel substrate. Trees present: alder, hickory, sycamore, walnut, cherry, ash, oak, and maple.
3	Cherry Run downstream from disposal area tributary	Stream 5 to 6 meters wide and up to 0.5 meter deep; cobble-pebble bottom with some rubble and bedrock. Stream banks lined with willow, wild cherry, and crabapple. Some silt over rocks.
4	Tributary to Cherry Run north of refuse area	Small, high-gradient stream. Riffles 1 to 2 meters wide and 0.2 meter deep; pools 2 to 3 meters wide and up to 0.5 meter deep. Substrate was cobble and rubble in general with some silt in pools. Scattered trees and bushy fields on banks. Trees present: cherry, dogwood, and alder.
5	Tributary to Cherry Run south of refuse area (upstream)	Small stream flowing through wooded area dominated by cherry, maple, alder, and brushy scrubs. Stream up to 1 meter wide and 0.2 meter deep; riffle substrate was cobble-rubble. Pools were up to 0.5 meter deep with silt, sand, and gravel bottom.
6	Tributary to Cherry Run south of refuse area (near mouth)	Stream 1 to 1.5 meters wide and 0.3 to 0.4 meter deep; riffle-run habitat with cobble-rubble substrate overlying pebble-gravel. Stream banks lined with alder, willow, and elderberry.
7	Tributary to **Wier's** Run below ash disposal area	Intermittent tributary 0.5 to 1.0 meter wide, 0.1 to 0.2 meter deep, substrate cobble, rubble, some small pools. Trees along stream were shagbark, redoak, ash, cherry, sassafras, beech, ironwood, dogwood.
8	**Wier's** Run downstream from ash disposal area	Stream averaged 0.5 meter wide; and 0.1 to 0.2 meter deep. A few small pools. Ferric hydroxide coating on stones. Pebble-cobble substrate. Stream banks lined with alder, cherry, ironwood, hickory, and redoak.
9	**Wier's** Run 1.0 km south of ash disposal area	Stream was $\sim$1.5 meters wide and 0.2 to 0.3 meter deep in riffle areas with pebble-cobble substrate. Pools 0.5 to 0.8 meter deep with silty substrate. Trees were alder, cherry, crabapple, walnut, and ironwood. Septic tank draining into stream at this site.

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TABLE 71. (Continued)

Site[a]	Location	Description
10	**Wier's** Run at Mahan-School Road	Stream flows through wooded swamp. Banks lined with alder, oak, willow, sycamore, dogwood, shingle oak. Riffles 2 to 3 meters wide and 0.2 to 0.4 meter deep; pools up to 0.7 meter deep. Substrate cobble-rubble with occasional boulder.
11	Rager's Pond tributary	Stream has riffles and small pools. Area sampled was 1 to 2 meters wide and 0.2 meter deep. Substrate was pebble-cobble-rubble with some shale. All rocks were covered with a soft reddish orange precipitate. Wooded with cherry, oak, maple, hickory, and willow.
12	Common Ravine	Area sampled was mostly riffle, 1 to 1.5 meters wide and 0.25 meter deep. Substrate was pebble-cobble-rubble. Rocks were coated with white precipitate which cemented them together. Stream flowed through powerline cut, lined with small willows.
13	Two Lick Creek at Coral	Large stream over 30 meters wide. Substrate was cobble-rubble with some boulders. Substrate was covered with ferric hydroxide(?). Periphyton only collected near shore.
14	Ramsey's Run	Stream was generally 2 to 4 meters wide; riffles were 0.1 to 0.2 meter deep; pools were up to 0.5 meter deep. Substrate was gravel-pebble with occasional cobble-rubble. Stream flowed through wooded area with a closed canopy. Trees were alder, ironwood, cherry, and maple. Brown algae present on rocks.

(a) See Figure 25 for aquatic biota sampling locations.

Sampling and Analysis Procedures

Periphyton

Natural substrates were sampled in triplicate for hard-bodied periphyton. Knife scrapings taken from a 3.14-sq cm area on cobble-sized rocks were funneled into a sample bottle and preserved with an algal preservative composed of 60 percent water, 30 percent alcohol, and 10 percent formalin.

Quantitative procedures were utilized in the analysis of the periphyton samples. All samples were adjusted to a constant volume (20 ml) to normalize resultant data.

Diatoms in the samples were analyzed according to the following procedure:

- Half the sample was removed from each sample bottle with a pipette and treated with 30 percent H_2O_2 and $K_2Cr_2O_7$ to dissolve extraneous organic matter (including nondiatomaceous algae).
- Residue was washed with tap water; the supernatant liquid was decanted three to five times at 3-hour intervals until the sample cleared.
- 0.5 ml of sample was placed on a cover slip; water was evaporated from the cover slips on a slide warmer; cover slips were then placed on a hot plate for a minimum of 2 hours to combust any organic material which may have remained in the diatom frustules.
- Cover slips were fixed to slides using Hyrax mounting medium.
- Diatoms on each slide were identified to species under oil immersion with the aid of appropriate taxonomic keys.(D-2,D-3)
- Counts were made and recorded for 40 microscope fields or more, depending on sample density.

Benthic Macroinvertebrates

Benthic macroinvertebrates in and on natural substrates were collected from riffle areas with a Surber sampler. Five replicate samples were taken at all stations. These samples were placed in individual bottles, preserved with formalin, and returned to BCL for sorting, identification, and enumeration.

Organisms from unsorted Surber samples were separated from silt and debris by passing the sample through a U.S. 30-mesh sieve. The remaining materials were then sorted, taking only those organisms remaining on the screen.

All benthic organisms were identified with the aid of a stereoscopic microscope. Identification was made to the lowest practical taxon utilizing appropriate taxonomic keys.(D-4,D-9) Midge larvae were mounted on slides and identified under a compound microscope according to the procedure presented by Mason.(D-4) Species diversities were calculated using the Shannon-Weaver formula.(D-10)

Fishes

Fishes were collected during the winter survey utilizing a 4x6-foot, 1/4-inch mesh seine. Spring collections were made using the seine and/or a back pack shocker. Fishing was conducted with approximately equal effort (1/2 hour) at each station. Fishes were identified, recorded, and released. Specimens not positively identified in the field were placed in sample bottles, preserved, and returned to the laboratory for identification.

Fishes were collected at selected sites during the spring survey for tissue analyses of nickel, copper, arsenic, and zinc. The whole fishes were held on wet ice, filleted (or in the case of the shiners and minnows, left whole), frozen on dry ice, and shipped to Tradet, Inc., for analyses.

Detailed Data

The types and numbers of species collected for all three organisms are given in Tables 72 through 87.

TABLE 72. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM CHERRY RUN, DECEMBER 13-17, 1976

	Upstream of plant outfalls		Downstream of railroad bridge		Downstream of disposal area tributary	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
	Standing crops, organisms/cm^2					
Achnanthes linearis	9,000	41,000			51,000	87,000
Amphipleura pellucida						5,000
Amphora ovalis				9,000		
Cocconeis placentula v. *euglypta*			70			
Cymbella tumida			70	18,000		
C. ventricosa				5,000	5,000	
Fragilaria vaucheriae			100	5,000	9,000	9,000
Frustulia rhomboides v. *amphipleuroides*				9,000		
Frustulia vulgaris				5,000		
Gomphonema acuminatum		5,000				
G. angustatum v. *producta*				5,000	5,000	
G. sphaerophorum		18,000				
Hantzschia amphioxys						5,000
Melosira distans		46,000		37,000		60,000
Meridion circulare			100			
Navicula anglica v. *subsalsa*					5,000	
N. cryptocephala		5,000		41,000		18,000
N. miniscula	5,000					
N. radiosa				28,000	18,000	28,000
N. rhyncocephala			200			
N. tripunctata				9,000		
N. viridula			500			9,000
Nitzschia amphibia				138,000		
N. apiculata				5,000		
N. clausii				9,000	18,000	32,000
N. dissipata				32,000	9,000	5,000
N. ignorata					5,000	32,000
N. palea				9,000		37,000
Surirella angustata				5,000		
S. ovalis			400	18,000		5,000
Synedra acus			70			
S. pulchella					5,000	
S. rumpens	32,000	14,000	70	18,000		41,000
S. ulna						5,000
S. ulna v. *danica*			100			
S. ulna v. *subaequalis*		5,000				
S. sp.					9,000	
Total standing crops	46,000	134,000	1,680	405,000	139,000	378,000
	Number of Species					
	3	7	10	19	11	15

TABLE 73. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM CHERRY RUN, APRIL 11-15, 1977

	Cherry Run								
	Upstream of plant outfalls			Downstream of railroad bridge			Downstream of disposal area tributary		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	Standing crops, organisms/cm^2								
Achnanthes linearis		3,000					11,000	3,000	3,000
Amphipleura pellucida	2,000								
Bacillaria paradoxa		1,000							
Cymbella prostrata									3,000
C. turgida			No organisms				4,000		
C. ventricosa					900				3,000
Fragilaria vaucheriae					2,600	2,000	4,000		
Frustulia vulgaris									3,000
Gomphonema angustatum v. *producta*	2,000	4,000			3,500	8,000	14,000	10,000	27,000
G. constrictum	6,000								
G. parvulum	2,000	1,000		4,000			7,000	900	
Melosira distans				7,000	3,500	8,000	21,000	3,000	
Meridion circulare							4,000		
Navicula cryptocephala		3,000		4,000	900			2,000	
N. minscula	2,000						4,000		
N. radiosa	18,000				13,000	11,000		21,000	
N. tripunctata									3,000
N. virdula		14,000		29,000		23,000	63,000		12,000
Nitzschia dissipata		1,000							3,000
N. ignorata								900	
N. linearis					1,700	2,000			
N. palea							11,000		
Pinnularia sp.									3,000
Rhoicosphenia curvata							4,000		
Surirella ovata				4,000	900		4,000	900	
S. sp.		1,000				2,000			
Synedra rumpens							4,000		
S. ulna					1,700				
S. sp.					2,600				
Total standing crops	34,000	28,000	0	48,000	31,300	56,000	155,000	32,700	60,000
	Number of species								
	6	8	0	5	10	7	13	8	9

TABLE 74. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM THREE TRIBUTARY STREAMS IN THE VICINITY OF THE HOMER CITY POWER COMPLEX PROPOSED REFUSE AREA, DECEMBER 13-17, 1976

	Tributary north of refuse area		Tributary south of refuse area		Mouth of tributary south of refuse area	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
	Standing crops, organisms/cm^2					
Achnanthes linearis	9,000				543,000	
Caloneis bacillum	110,000				9,000	
Fragilaria vaucheriae					9,000	
Gomphonema acuminatum			9,000			
Melosira ambigua		41,000				800
M. distans	46,000	37,000				
M. varians					64,000	
Navicula salinarum v. *intermedia*					9,000	
N. radiosa		5,000	28,000	28,000		
N. viridula	110,000		23,000			
N. sp.						70
Nitzschia amphibia				14,000		
N. fonticola					92,000	
N. palea			9,000		9,000	40
Surirella angustata			5,000			
S. ovalis	9,000		5,000	18,000	9,000	
Synedra pulchella						40
Total Standing Crops	284,000	83,000	79,000	60,000	744,000	950
	Number of species					
	5	3	6	3	8	4

TABLE 75. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM THREE TRIBUTARY STREAMS IN THE VICINITY OF THE HOMER CITY POWER COMPLEX PROPOSED REFUSE AREA, DECEMBER 13-17, 1976

	Tributary north of refuse area			Tributary south of refuse area			Mouth of tributary south of refuse area		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
				Standing crops, organisms/cm^2					
Achnanthes lanceolata	12,000			3,000					
Cymbella amphicephala			6,000						
C. sp.						8,000			
Fragilaria vaucheriae						8,000			
Frustulia vulgaris					11,000				
Gomphonema angustatum v. *producta*		1,000	3,000						
G. parvulum			8,000		39,000	8,000			
Gyrosigma sp.							10	5	
Melosira ambigua			6,000						90
M. distans		12,000		13,000					20
Meridion circulare			3,000		6,000				
Navicula cryptocephala	22,000		3,000	6,000	28,000	23,000		5	30
N. radiosa	16,00	17,000	42,000	80,000	72,000	105,000	30		90
N. salinarum v. *intermedia*				10,000				210	
N. viridula	105,000			3,000					
N. sp.			3,000						
Nitzschia linearis		1,000							
N. palea			6,000						
Pinnularia sp.				3,000					
Rhoicosphenia curvata								20	
Surirella angustata						8,000			
S. ovata	90,000	13,000	45,000	64,000	413,000	315,000		5	
S. ovata v. *pinnata*					11,000				
Synedra rumpens		5,000				8,000			
S. ulna								5	10
Tabellaria fenestrata			8,000						
Total standing crops	245,000	49,000	133,000	182,000	580,000	483,000	40	250	240
				Number of species					
	5	6	11	8	7	8	2	6	5

TABLE 76. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM WIER'S RUN, DECEMBER 13-17, 1976

	Wier's Run					
	Downstream of ash disposal area		1.0 km south of ash disposal area		At Mahan School Road	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
	Standing crops, organisms/cm^2					
Achnanthes linearis			23,000		28,000	64,000
Amphora ovalis v. *pediculus*						5,000
Diatoma vulgare			83,000	41,000	23,000	120,000
Gomphonema angustatum v. *producta*			5,000	5,000	9,000	
G. parvulum					5,000	5,000
Melosira distans						28,000
M. varians	300					
Navicula cryptocephala					5,000	14,000
N. pelliculosa			5,000			
N. salinarum v. *intermedia*					5,000	
N. radiosa					37,000	78,000
Nitzschia amphibia						46,000
N. apiculata						5,000
N. dissipata					5,000	18,000
N. palea		40				
Pinnularia sp.				5,000		
Synedra pulchella					14,000	23,000
S. ulna		100				
Total Standing Crops	300	140	116,000	51,000	131,000	406,000
	Number of species					
	1	2	4	3	9	11

TABLE 77. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM WIER'S RUN, APRIL 11-15, 1977

	Wier's Run								
	Downstream from ash disposal area			1.0 km south of ash disposal area			At Mahan School Road		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
	Standing crops/organisms cm^2								
Achnanthes lanceolata									
A. linearis							3,000		
Cymbella amphicephala	40		20		70	70			
C. ventricosa								20	
Diatoma vulgare							1,200		
D. vulgare v. *breve*		10							
Fragilaria vaucheriae				30	20				
Gomphonema parvulum							6,000	40	
G. tergestinum							3,000		
Meridion circulare							1,000		
Melosira ambigua	50								
M. distans	180	60		90	250		4,000		
Navicula cryptocephala	20		80		50	50	3,000		
N. radiosa	20				210	20	2,000	40	30
N. salinarum v. *intermedia*		10							
N. Tripunctata		30			20				
N. viridula				30	40				
N. sp.			100						
Nitzschia ignorata				270	180	290			
N. linearis					20	20			
N. palea					20				
Pinnularia braunii v. *amphicephala*						20			
P sp.		10							
Stauroneis anceps	20			30					
Surirella ovalis	20						1,000		
S. sp.						20			
Synedra pulchella				90				60	60
S. ulna					40	430	10,000	40	
S. sp.						70			
Total Standing Crops	350	120	200	540	940	990	45,000	200	90
	Number of species								
	7	5	3	6	12	9	10	5	2

TABLE 78. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM THREE TRIBUTARY STREAMS IN THE VICINITY OF THE HOMER CITY POWER COMPLEX, DECEMBER 13-17, 1976

	Tributary to Wier's Run		Common Ravine		Rager's Pond Tributary	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
	Standing crops, organisms/cm^2					
Achnanthes linearis	856,000	110,000				
Cymbella tumida		9,000				
C. turgida	18,000					
Diatoma vulgare				40	200	No organisms
Fragilaria vaucheriae		74,000				
Gomphonema angustatum v. *producta*	28,000	37,000	40			
G. parvulum	18,000					
Melosira ambigua				740		
M. distans				590		
Navicula radiosa					40	
Nitzschia amphibia		9,000				
N. dissipata		18,000				
N. fonticola	9,000					
N. palea				110		
Synedra rumpens	92,000	64,000				
Total Standing Crops	1,021,000	321,000	40	1,480	240	0
	Number of species					
	6	7	1	4	2	0

TABLE 79. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM THREE TRIBUTARY STREAMS IN THE VICINITY OF THE HOMER CITY POWER COMPLEX, APRIL 11-15, 1977

	Tributary to Wier's Run			Common Ravine			Rager's Pond tributary		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
				Standing crops, organisms/cm^2					
Achnanthes linearis	7,000	56,000							
Cymbella amphicephala	137,000	51,000	202,000						
C. ventricosa	7,000	41,000	3,000						
Eunotia exigua									60
Fragilaria leptostauron v. *dubia*		5,000							
F. vaucheriae	7,000	5,000	26,000						
Gomphonema angustatum v. *producta*	4,000	10,000	3,000						
G. parvulum		168,000	3,000						
Melosira ambigua				60	530	120			
M. distans				140	160	60			180
M. varians			10,000						
Meridion circulare					20				
Navicula cryptocephala						30			
N. radiosa						30			
N. tripunctata				20	50		30	30	60
N. sp.									60
Nitzschia amphibia	4,000								
N. dissipata				10					
N. linearis	4,000								
N. palea		5,000	3,000						
N. tryblionella v. *debilis*		5,000							
Surirella sp.						30			
Stauroneis anceps				30					
Stephanodiscus astraea		5,000							
Synedra rumpens	4,000		13,000						
S. ulna	4,000	6,000							
Total standing crops	178,000	357,000	263,000	260	760	270	30	30	360
				Number of Species					
	9	11	8	5	4	5	1	1	4

TABLE 80. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM TWO LICK CREEK AND RAMSEY RUN, DECEMBER 13-17, 1976

	Two Lick Creek		Ramsey Run	
	Sample 1	Sample 2	Sample 1	Sample 2
	Standing crops, organisms/cm^2			
Asterionella formosa	160			
Caloneis bacillum		40		
Cymbella turgida	40			
C. ventricosa	40			
Eunotia sp.	40	40		
Fragilaria vaucheriae			9,000	
Frustulia vulgaris	40			
Gomphonema angustatum v. *producta*	80			9,000
Melosira ambigua		900		
M. distans	480	320		
Navicula cryptocephala		40		83,000
N. miniscula				9,000
N. salinarum v. *intermedia*	40		18,000	
N. radiosa		120		64,000
N. viridula			285,000	239,000
N. sp.			9,000	
Nitzschia amphibia				9,000
N. dissipata		40		9,000
N. fonticola	40			
N. palea		80	9,000	18,000
Pinnularia sp.	40			
Stephanodiscus astraea		80		
Surirella ovalis	40	40	9,000	
Tabellaria quadrisepta		40		
Total Standing Crops	1,040	1,740	339,000	440,000
	Number of species			
	11	11	61	8

TABLE 81. DIATOM SPECIES AND STANDING CROPS COLLECTED FROM TWO LICK CREEK AND RAMSEY RUN, APRIL 11-15, 1977

	Two Lick Creek			Ramsey Run		
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
			Standing crops/organisms cm^2			
Achnanthes lanceolata	20	50				
Amphiprora ornata	20					
Cymbella amphicephala	100					
Eunotia exigua		300	120			
E. sp.			30			
Frustulia vulgaris			30			
Gomphonema parvulum				6,000		
Melosira ambigua	100	120				
M. distans	260	180	120	40,000		
Meridion circulare	20		30			
Navicula cryptocephala			60	23,000		43,000
N. lanceolata				542,000	389,000	682,000
N. miniscula					4,000	
N. radiosa	70	90			68,000	
N. salinarum v. *intermedia*					10,000	
N. tripunctata	20		30			
Nitzschia dissipata					4,000	
N. ignorata			30			
N. palea			30	6,000		
Pinnularia braunii v. *amphicephala*	20	70	30			
P. sp.			30			
Surirella angustata		50				
S. linearis	120					
S. orata		20		40,000	7,000	7,000
Synedra rumpens	20					
S. sp.			30			
Total standing crops	770	880	570	657,000	482,000	732,000
			Number of species			
	11	8	12	6	6	3

TABLE 82. BENTHIC MACROINVERTEBRATES COLLECTED WITH A SURBER SAMPLER FROM STREAMS IN THE AREA OF THE HOMER CITY POWER COMPLEX, DECEMBER 13-17, 1976

Site:(a)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DIPTERA														
Chironomidae														
Pentaneura sp.		1		1			2							
Microtendipes sp.	4	2												
Cricotopsus sp.	1	6		1			3			8				11
Smittia sp.				9	14									
Diamesa sp.				1			3			3				
Unidentified sp.	1						1							
Tipulidae														
Tipula sp.	1			9	10		9							1
Hexatoma sp.	3			1	1									
Antocha sp.				1						4				
Dicranota sp.					3									
Tabanidae														
Chrypops sp.				1	5		4		1					5
Simuliidae														
Simulium sp.	1		1											
Ceratopogonidae														
Palpomyia sp.							1							
Empididae														
Sp. A	2		1						1	1				
Sp. B	1			20					1					
EPHEMEROPTERA														
Baetidae														
Caenis sp.	1					1								
Ephemerella sp.					11				1					
Paraleptophlebia sp.				3										
Heptageniidae														
Stenonema sp.	5			5	8			4	1					

TABLE 82. (Continued)

Site:[(a)]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PLECOPTERA														
Peltoperlidae														
Peltoperla sp.						1								
Nemouridae														
Taeniopteryx sp.														1
Allocapnia sp.	12			3			2		2					1
Perlidae														
Acroneuria sp.				1										
Chloroperlidae														
Isoperla sp.					6									
TRICHOPTERA														
Rhyacophilidae														
Agapetus sp.				21	20		3							2
Rhyacophila sp.			1	1	3									
Glossosoma sp.	1					1								
Hydropsychidae														
Hydropsyche sp.	1	1		27	26		5		5	101				20
Cheumatopsyche sp.	20	3	2	55	48	3	65		7	424				9
Unidentified sp.				2	25				4					
Limnephilidae														
Astenophylax sp.					1									
Philopotamidae														
Chimarra sp.				26	3									9
Leptoceridae														
Athripsodes sp.							1							
MEGALOPTERA														
Sialidae														
Sialis sp.	2				2	1								
Corydalidae														
Chauloides sp.				1										2

TABLE 82. (Continued)

Site:[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
COLEOPTERA														
Elmidae														
Stenelmis sp.	4			1			13							11
Optioservus sp.			2	4						1				
Unidentified sp.	2			5			4							
Psephenidae				3										
Psephenus sp.				3										
PELECYPODA														
Sphaeriidae														
Sphaerium sp.	24	104	1	1										
GASTROPODA														
Ancylidae														
Ferrissia sp.	2		2											3
DECAPODA														
Astacidae														
Cambarus sp.							1							
Orconectes sp.		1		1										
OLIGOCHAETA														
Unidentified sp.		2												23
NEMATODA														
Total No. Individuals	88	120	10	204	186	7	121	0	23	542	0	0	-	100
Total No. Species	19	8	7	26	16	5	16	0	9	7	0	0	-	15
Species Diversity Index	3.28	0.90	2.72	3.50	3.32	2.13	2.61	0	2.73	0.95	0	0	-	3.20

(a) See Figure 25 for aquatic biota sampling locations.

TABLE 83. BENTHIC MACROINVERTEBRATES COLLECTED WITH A SURBER SAMPLER FROM STREAMS IN THE AREA OF THE HOMER CITY POWER COMPLEX, APRIL 11-15, 1977

Site:[(a)]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DIPTERA														
Chironomidae														
Pentaneura sp.														1
Microtendipes sp.							4							
Cricotopus sp.	1	5		6			1							22
Diamesa sp.					25					1				
Tipulidae														
Tipula sp.					1									
Hexatoma sp.				2			2							
Dicranota sp.														1
Tabanidae														
Tabanus sp.				1										
Ceratopogonidae														
Palpomyia sp.														1
Empididae														
Sp. A		1		1			3							3
EPEMEROPTERA														
Ephemeridae														
Ephemera sp.				1			1							
Baetidae														
Baetis sp.				3										
Ephemerella sp.				6	1									
Paraleptophilibia sp.				1										
Heptageniidae														
Heptagenia sp.				2										
Stenonema sp.	1	2		10	3		3							

TABLE 83. (Continued)

Site:[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PLECOPTERA														
Nemouridae														
Allocapnia sp.				1										
Perlidae														
Acroneuria sp.						1								
Chloroperlidae														
Isoperla sp.			1	13	2									1
TRICHOPTERA														
Rhyacophilidae														
Agapetus sp. A				11	26		2							
Agapetus sp. B							3							
Rhyacophila sp.				10										1
Protoptila sp.							2							
Hydropsychidae														
Hydropsyche sp.		9	2	13	34		32			7				1
Cheumatopsyche sp.		2		11	19	2	30			4				1
Unidentified sp.				1			1							
Philopotamidae														
Chimarra sp.				5										2
ODONATA														
Gomphidae														
Hagenius sp.				1										
HEMIPTERA														
Veliidae														
Microvelia sp.							1							
MEGALOPTERA														
Sialidae														
Sialis sp.					1									

TABLE 83. (Continued)

Site:[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Corydalidae														
Chavloides sp.	1													
COLEOPTERA														
Elmidae														
Stenelmis sp.	5			14	1		114							6
Optioservus sp.				26	2					2				
Cleptelmis sp.					2									
Psephenidae														
Psephenus sp.				8										
Unidentified sp.							1							
PELECYPODA														
Sphaeriidae														
Sphaerium sp.	4	6	1											
GASTROPODA														
Ancylidae														
Ferrissia sp.			1											
DECAPODA														
Astacidae														
Cambarus sp.				3										
ISOPODA														
Asellidae														
Asellus sp.										1				
OLIGOCHAETA sp.				2			2			2				7

TABLE 83. (Continued)

Site:[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
NEMATODA sp.	1													
Total number of Individuals	13	25	5	152	117	3	202	0	0	17	0	0	0	47
Total Number of Species	6	6	4	24	12	2	16	0	0	6	0	0	0	12
Species Diversity Index	2.19	2.25	1.92	3.98	2.57	0.92	2.13	0	0	2.23	0	0	0	2.58

(a) See Figure 25 for aquatic biota sampling locations.

TABLE 84. FISH SPECIES SURVEYED AND COLLECTED FROM STREAM SITES IN THE VICINITY OF THE HOMER CITY POWER COMPLEX, DECEMBER 13-17, 1976

Species	Number of individuals surveyed at sites indicated[a][b]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Silverjaw minnow *(Ericymba buccata)*				1										
Stoneroller minnow *(Campostoma anomalum)*		3	3	7										1
Bluntnose minnow *(Pimephales notatus)*	2		5	3						1				
Creek chub *(Semotilus atromaculatus)*			3	3	8	1			4	5				4
Blacknose dace *(Rhinichthys atratulus)*				5	8				1					7
Silver shiner *(Notropis photogenis)*	1	1	1											
Striped shiner *(Notropis chrysocephalus)*				3										
Hogsucker *(Hypentelium nigricans)*	1	3		2										
Common white sucker *(Catostomus commersoni)*				1						2				
Golden redhorse sucker *(Moxostoma erythrurum)*			1											
Barred fantail darter *(Etheostoma flabellare)*	8	20	3	11		1								
Johnny darter *(Etheostoma nigrum)*	1		2	7										
Mottled sculpin *(Cottus bairdi)*										2				35
Smallmouth bass *(Micropterus dolomieui)*	1													
Rock bass *(Ambloplites rupestris)*			2											
Pumpkinseed sunfish *(Lepomis gibbosus)*	1													

(a) A visual appraisal of the stream habitats at Sites 7, 8, 11, 12, and 13 indicated that seining for fish would not be worthwhile.

(b) See Figure 25 for aquatic biota sampling locations.

TABLE 85. FISH SPECIES SURVEYED AND COLLECTED FROM STREAM SITES IN THE VICINITY OF THE HOMER CITY POWER COMPLEX, APRIL 11-15, 1977

Species	Number of individuals surveyed at sites indicated													
Site:(b)	1	2	3	4	5	6	7	8	9	10	11	12	13(a)	14
Least brook lamprey *(Okkelbergia aepyptera)*			5			3								
Silverjaw minnow *(Ericymba buccata)*		2	2											
Stoneroller minnow *(Campostoma anomalum)*	3	1	26	16										
Bluntnose minnow *(Pimephales notatus)*	32	18	3	2										
Creek chub *(Semotilus atromaculatus)*	20	2	12	44	12		5	6	20	14				12
Blacknose dace *(Rhinichthys atratulus)*			1	17	35				2					20
Silver shiner *(Notropis photogenis)*	2	5	4	2										
Striped shiner *(Notropis chrysocephalus)*	1			2										
Hogsucker *(Hypentelium nigricans)*	14	10	2	3										
Common white sucker *(Catostomus commersoni)*	1	1	22	12						5				1
Golden redhorse sucker *(Moxostoma erythrurum)*				2										2
Barred fantail darter *(Etheostoma flabellare)*	7	16	13	28		2								
Johnny darter *(Etheostoma nigrum)*		4	5	12										2
Mottled sculpin *(Cottus bairdi)*										3				30
Smallmouth bass *(Micropterus dolomieui)*	1													
Rock bass *(Ambloplites rupestris)*	4	4	1											
Pumpkinseed sunfish *(Lepomis gibbosus)*														
Bluegill *(Lepomis macrochirus)*	2	2	1											
Yellow perch *(Perca flavescens)*		1	5											

(a) No fish collections were attempted.

(b) See Figure 25 for aquatic biota sampling locations.

TABLE 86. CONCENTRATIONS OF FOUR HEAVY METALS IN FISH TISSUE SAMPLES FROM CHERRY RUN AND WIER'S RUN, APRIL 11-15, 1977

		Concentration, ppm			
		Arsenic	Copper	Nickel	Zinc
Cherry Run -- Upstream of Disposal Area (Site 1)					
Sediment[a]	Wet	4.1-8.97	14-263	43-89	36-231
	Dry	6.5-15	30-440	90-140	75-387
Tissue					
Hogsucker - 3; 3-5 in.	Wet	<0.04	35.0	11.7	33.4
	Dry	<0.3	196	65.9	187
Hogsucker - 1; 8 in.	Wet	0.023	44.3	3.48	20.7
	Dry	0.16	299	23.5	140
Hogsucker - 3; 2-5 in.	Wet	<0.051	13.7	10.1	26.0
	Dry	<0.37	99.5	73.1	189
White Sucker - 1; 5 in.	Wet	0.055	24.1	24.9	18.4
	Dry	0.26	113	117	86.4
Bluntnose Minnow[b,c] - 6; 2-4 in.	Wet	0.22	1.04	0.93	74.3
	Dry	0.90	4.20	3.78	301
Bluntnose Minnow[b] - 6; 2-4 in.	Wet	0.26	2.32	0.86	8.84
	Dry	0.96	8.41	3.12	32.0
Bluntnose Minnow[b,c] - 7; 2-4 in.	Wet	0.10	1.84	<0.4	64.1
	Dry	0.50	8.90	<2.0	311
Pumpkinseed Sunfish - 2; 3 in.	Wet	<0.11	44.2	6.84	15.1
	Dry	<0.70	274	42.4	110
Rockbass - 2; 5-6 in.	Wet	0.070	98.8	14.6	17.7
	Dry	0.31	433	63.9	77.5
Cherry Run -- Downstream From Disposal Area Tributary (Site 3)					
	Wet	3.0-3.6	15-152	46-55	24-128
	Dry	4.8-13.3	23-225	71-207	107-190
Hogsucker - 2; 10 in.	Wet	0.029	6.32	3.15	26.6
	Dry	0.13	27.3	13.6	115
White Sucker - 2; 10 in.	Wet	0.053	14.3	2.01	15.1
	Dry	0.28	76.0	10.7	80.5

TABLE 86. (Continued)

Sediment[c]		Arsenic	Copper	Nickel	Zinc
Tissue					
White Sucker - 3; 14 in.	Wet	<0.07	8.37	2.08	18.7
	Dry	<0.32	37.9	9.27	79.7
White Sucker - 2; 12 in.	Wet	0.047	5.73	1.01	13.9
	Dry	0.25	31.1	5.55	75.7
Bluntnose Minnow[b,c] - 2; 2.5 in.	Wet	<0.28	1.91	<0.9	72.4
	Dry	<1.4	9.56	<4.5	362
Stoneroller Minnow[b] - 4; 2-4 in.	Wet	0.20	131	2.98	88.7
	Dry	1.0	663	15.1	450
Stoneroller Minnow[b] - 4; 2-4 in.	Wet	0.26	87	11.2	66.7
	Dry	1.4	464	59.8	357
Stoneroller Minnow[b,c] - 3; 2-4 in.	Wet	0.24	2.33	1.37	39.0
	Dry	0.85	8.41	4.85	138
Bluegill - 1; 8 in.	Wet	0.087	53.2	14.8	18.8
	Dry	0.48	291	80.9	103
Wier's Run -- at Mahan School Road (Site 10)					
	Wet	4.8-5.4	19-154	49-55.4	59-120
	Dry	7.6-11.2	27-270	71-105	85-210
White Sucker - 3; 7 in.	Wet	<0.09	61	9.4	23
	Dry	<0.42	275	42.3	104

(a) Whole.
(b) Homogenized by hand with teflon and glass.
(c) Sample was taken approximately 2 stream miles upstream from fish tissue collection site.

TABLE 87. FISH SPECIES COLLECTED FROM STREAMS IN THE AREA OF THE HOMER CITY POWER COMPLEX

	Cherry Run	North tributary to Cherry Run	South tributary to Cherry Run	Tributary to Wier's Run	Wier's Run	Rager's Pond tributary	Treatment plant tributary	Ramsey's Run
Least brook lamprey	X							
Silverjaw minnow	X	X						
Stoneroller minnow	X	X						X
Bluntnose minnow	X	X			X			
Creek chub	X	X	X	X	X			X
Blacknose dace	X	X	X		X			X
Silver shiner	X	X						
Striped shiner	X	X						
Hogsucker	X	X						
Common white sucker	X	X			X			X
Golden redhorse sucker	X	X						X
Barred fantail darter	X	X						
Johnny darter	X	X						X
Mottled sculpin					X			X
Smallmouth bass	X							
Rock bass	X							
Pumpkinseed sunfish	X							
Bluegill	X							
Yellow perch	X							

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GLOSSARY

acidity: The base-neutralizing capacity of a water measured as the amount of sodium hydroxide required to titrate a sample generally to a pH of 8.3 and expressed as mg/l of equivalent $CaCO_3$. Strong mineral acids, weak acids such as carbonic and acetic, and hydrolysable metal salts such as ferrous or aluminum contribute to the acidity depending on the analytical method used.

alkalinity: The acid-neutralizing capacity of a water measured as the amount of 0.1 N acid required to titrate the sample to a pH of 4.5 and expressed in mill equivalents or in milligrams as equivalent $CaCO_3$. The major contributors to the alkalinity in most natural waters are the carbonates.

benthic macroinvertebrates: (benthic) Relating to or occurring at the bottom of a body of water. (invertebrate) Lacking a spinal column.

buffer capacity: The ability of a natural water to resist changes in pH. The buffer capacity, , is defined as the amount of a fully dissociated acid such as hydrochloric required to decrease the pH by one unit or the amount of strong base, for example, sodium hydroxide, to increase it by one unit.

colloids: Substances that, in contrast to crystalloids, are not distributed as individual molecules or ions in a liquid but rather as larger aggregates of molecules; hence, they are intermediate between true solutions and suspensions.

depauperate: Falling short of natural development or size.

diatom: Any of a class (*Bacillariophyceae*) of minute planktonic unicellular or colonial algae with silicified skeletons that form diatomite.

dipteran: Of, relating to, or being a two-winged fly.

Eh: A measure of the oxidizing or reducing tendency of a water or sediment. More positive Eh values indicate a system in which oxidized products such as sulfate, nitrate, and ferric iron are favored over their reduced counterparts--sulfide, ammonia, and ferrous iron, respectively.

fugitive dust emissions: As used in this study, particulate matter that becomes airborne due to forces of wind, man's activity, or both. Fugitive dust emissions may include traffic-generated particulate matter from unpaved roads, exposed surface areas at construction sites, and exposed storage piles.

Gaussian distribution: A normal distribution described graphically by a bell-shaped curve where 68 percent of the pollutant molecules are found within one standard deviation and 96 percent within 2 standard deviations.

hi-vol air sampler: An instrument in which a relatively large volume of air (1.5-2.0 cubic meters per minute) passes through a filter and the suspended particulate is captured in the process on the filter. Concentration of the suspended particulate in the atmosphere is reported as micrograms per cubic meter of air.

hydrolysis: The partial splitting caused by water of a neutral salt into its component-free acid and base; according to the strength of these products the solution reacts acidic or alkaline.

indicator species: An organism associated with particular environmental conditions whose presence is indicative of the existence of these conditions.

microscopic analysis: As used in this study, involves the examination of the high-volume filters under a microscope to determine particle type such as coal, ash, or soot and to quantify the coal or ash particles.

particle-sizing sampler: A four-stage multi-orifice, high-volume impactor with a back-up filter, which can be operated as a component of a standard high-volume sampler. The sampler separates the particulates in five size ranges: 7 microns or larger, 3.3 to 7 microns, 2.0-3.3 microns, 1.1-3.0 mocrons, and 0.01-1.1 microns.

periphyton: Organisms (as some algae) that live attached to underwater surfaces.

plume centerline: That hieght which is the midway between the top and bottom edges of the plume. The maximum pollutant concentrations are assumed in diffusion modeling to be found along the plume centerline.

scatter about line of regression: A measure of the variability of data points about the line of regression.

standing crops: The instantaneous living population. The biomass present in a body of water at a particular time.

Taxa (Plural of taxon): A classification of plants or animals according to their presumed natural relationships.

Trichopteran: Any of an order (Trichoptera) of insects.

virtual point source: A mathematical technique which combines all the emissions within a given area to an imaginary point source located upwind of the area source. A virtual distance, x_y, is determined by approximating the initial horizontal standard deviation as S/4.3 where S is the length of a side of the area.